Author: **James T. Goulding**
Department: **Mechanical Engineering**
Date: **1/31/00**

Program - Project - Job: SNS-FE Project
MEBT Mechanical Systems

Title: **SNS-FE MEBT 30mm & 40mm Beam Position Monitor Mechanical Design**

1. Scope

This engineering note describes the mechanical design for the 30mm Beam Position Monitor (BPM) and the 40mm Beam Position Monitor. It includes a drawing list of mechanical components and assemblies, design background, engineering calculations, outside vendor component information, and rendered pictures.

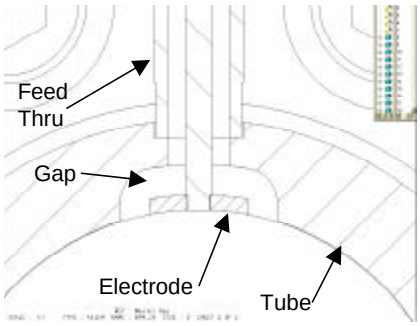
2. Drawings

2.1. 25B170 30mm BPM Bellows
2.2. 25B171 BPM SMA Feed Thru
2.3. 25B172 40mm BPM Bellows
2.4. 25B173 30mm BPM Bore Tube
2.5. 25B174 30mm BPM Electrode Spool
2.6. 25B175 30mm BPM Bellows Seal Flange
2.7. 25B176 30mm BPM Fixed Flange
2.8. 25B177 30mm BPM Split Flange
2.9. 25B178 30mm Beam Position Monitor
2.10. 25B179 40mm BPM Fixed Flange
2.11. 25B180 40mm BPM Electrode Spool
2.12. 25B181 40mm BPM Split Flange
2.13. 25B182 40mm BPM Bellows Seal Flange
2.14. 25B183 40mm BPM Bore Tube
2.15. 25B184 40mm Beam Position Monitor

Copies of all drawings are included in the Appendix

3. Design Overview

The BPM is based on the design of a 20mm stripline beam position monitor (LANL drawing no. 144Y-618019) that was developed at Los Alamos National Laboratory for the ADT CCDTL. The MEBT design differs from the LANL design in that machining the electrodes from a single spool of stainless steel. The base of the spool electrically shorts the electrodes together. The signal is taken from the free end through a microwave feed-through. The slots in the bore tubes (25B173 & 25B183) and the stripline tines on the electrode spool (25B174 & 25B180) were designed to maintain a 50Ω impedance. (For details of the electrical analysis, see SNS-Technical Note FE-EE-012.) The grounded stripline design



requires half as many feed-throughs and should simplify assembly fixturing.

To maintain the 50Ω impedance, the geometry of the electrode, the slot and the gap between them had to be within a tolerance of ±5% of nominal. The tolerance stack and tolerance sizing calculations are shown in the Appendix. Design issues included sizing the bellows, and having clearance for the mounting hardware.

4. Reference

4.1. CCDTL BPM Segment 6/7 20mm Bore, Drawing No. 114Y618019 (Los Alamos National Laboratory)
4.2. CCDTL BPM Segment 107/108 25mm Bore, Drawing No. 114Y618050 (Los Alamos National Laboratory)
4.3. Ultra-High Vacuum Microwave Feed-Through, SMA Female (Spec Sheet), Kaman Instrumentation Publication SMA-1000-3/95. (Copy of spec sheet included in Appendix.)
4.4. Contour Plot of Electrostatic Potential (included in the Appendix).
4.5. SNS Technical Note FE-EE-012, *Basic Electrical Design of the MEBT BPM*
4.6. Engineering Calculation Notes (included in appendix).
4.7. Standard Bellows Company homepage: www.std-bellows.com

5. Fabrication and Assembly Issues

Most of the component fabrication can be done with conventional milling and turning operations. However, the following features will be done using wire EDM:

- Bore tube inside diameter
- Bore tube slots on inside diameter
- Spool inside diameter
- Spool electrode tines

The wire EDM allows for better precision on the tighter profile callouts. It also allows for better thin wall cuts.

Because of the design, it is extremely difficult to make internal welds. External welding is far more practical. To help minimize the problem of virtual leaks caused by external welds, all fabricated components are ultra-high vacuum cleaned and electropolished before being welded into the assembly. Since they will be sitting on the shelf for months after assembly, another cleaning (water based) may be required. The vacuum in the beam pipe will in the 10^{-6} to 10^{-8} torrs range.

The feed-throughs are connected to the electrode tines to maintain electrical contact. The electrode is made of 316 stainless steel and the feed-through conductor is made of TZM (see spec sheet in Appendix D). Because the melting point of TZM is so high compared to 316 stainless steel, these two materials are not well suited for TIG welding. Torch brazing is a potential method, however there is a worry that the heat involved could cause the TZM to crystallize and crack. Another route is soldering. This would require the connection point on each component to be pre-tinned then assembled and heated to make the connection.

6. SNS-FE Personnel

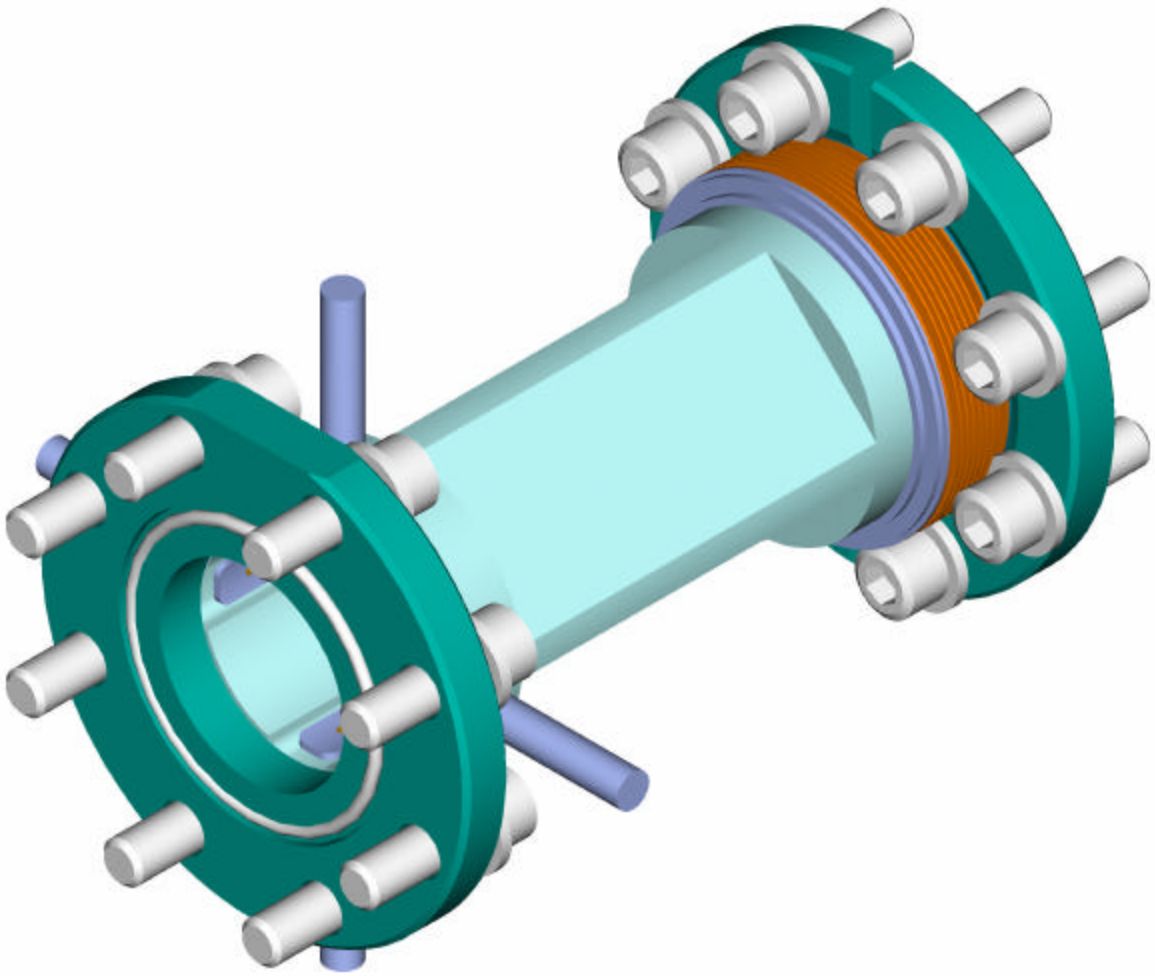
Daryl Oshatz, MEBT Lead Mechanical Engineer
James T. Goulding, Mechanical Engineer
Larry Doolittle, Electrical Engineer

6. Appendices

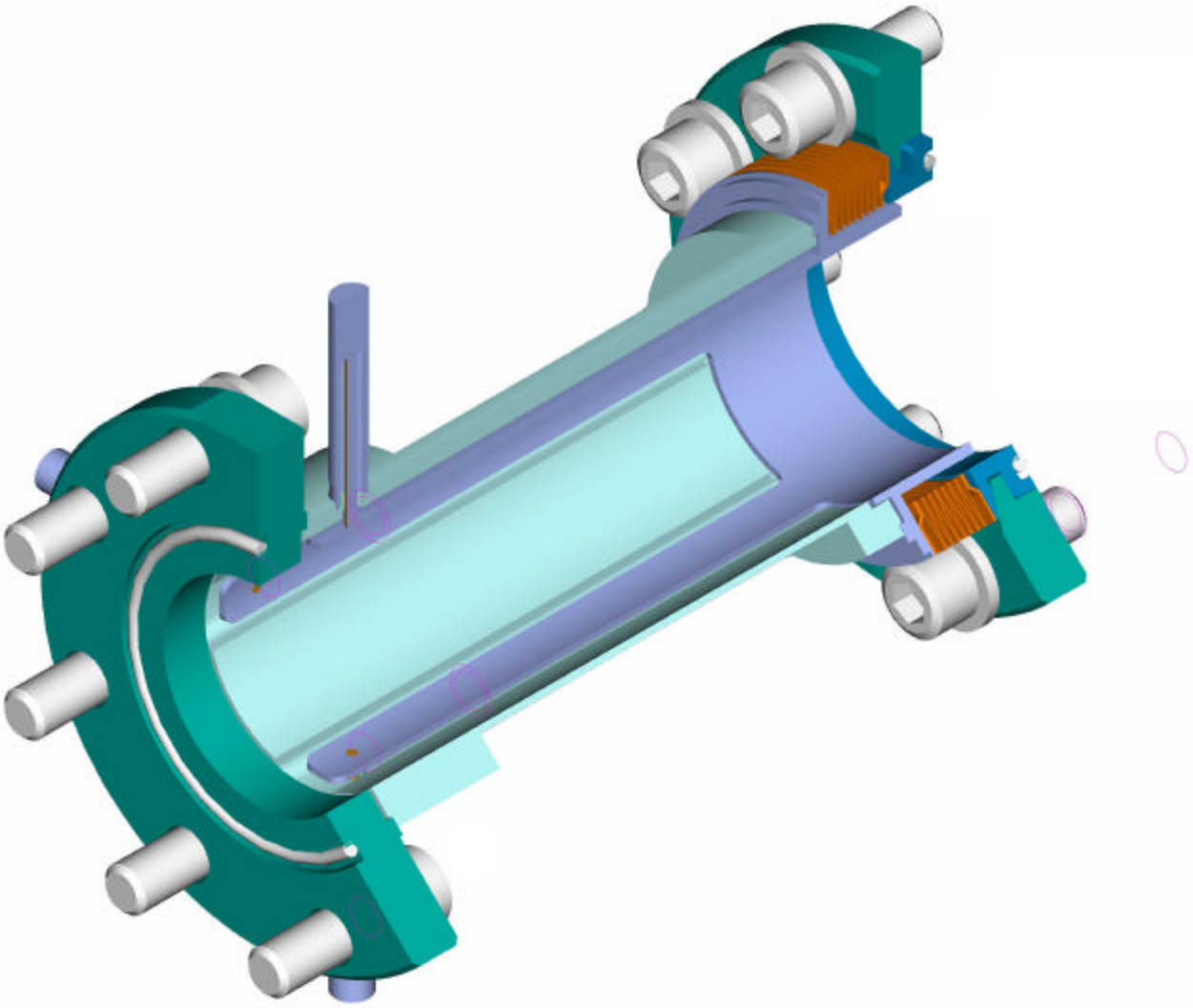
Appendix A: Rendered Pictures of 3-D CAD model
Appendix B: Component and Assembly Drawings
Appendix C: Engineering Calculations and Plots
Appendix D: Vendor Specification Sheets

Appendix A

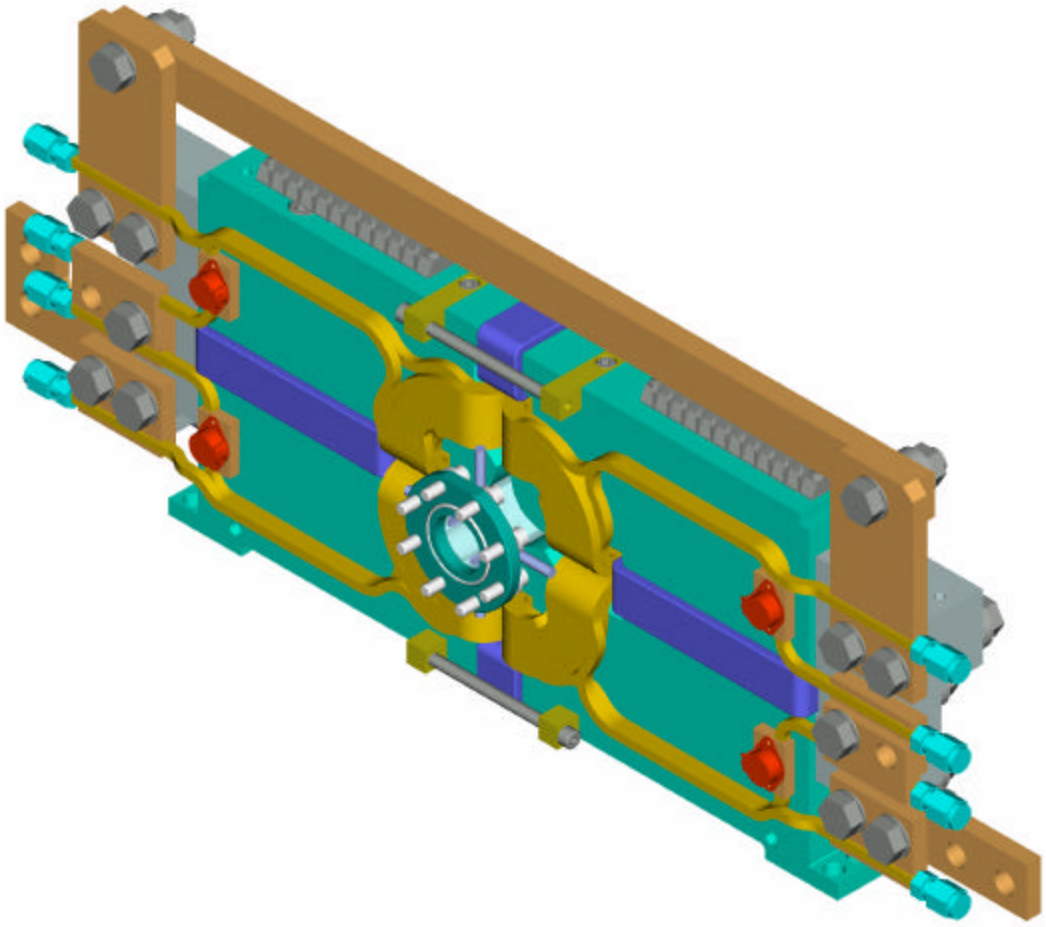
30 mm Beam Position Monitor



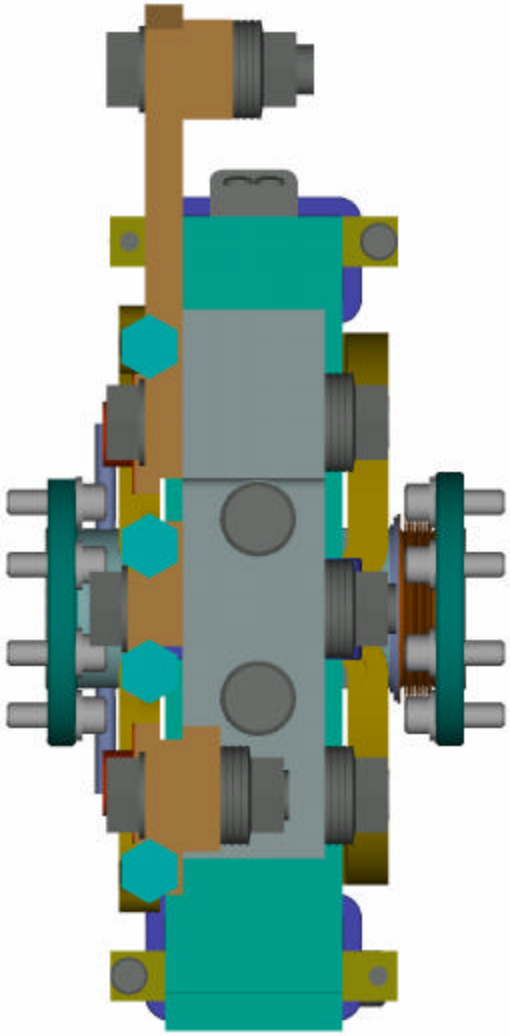
30mm BPM Cross Section View



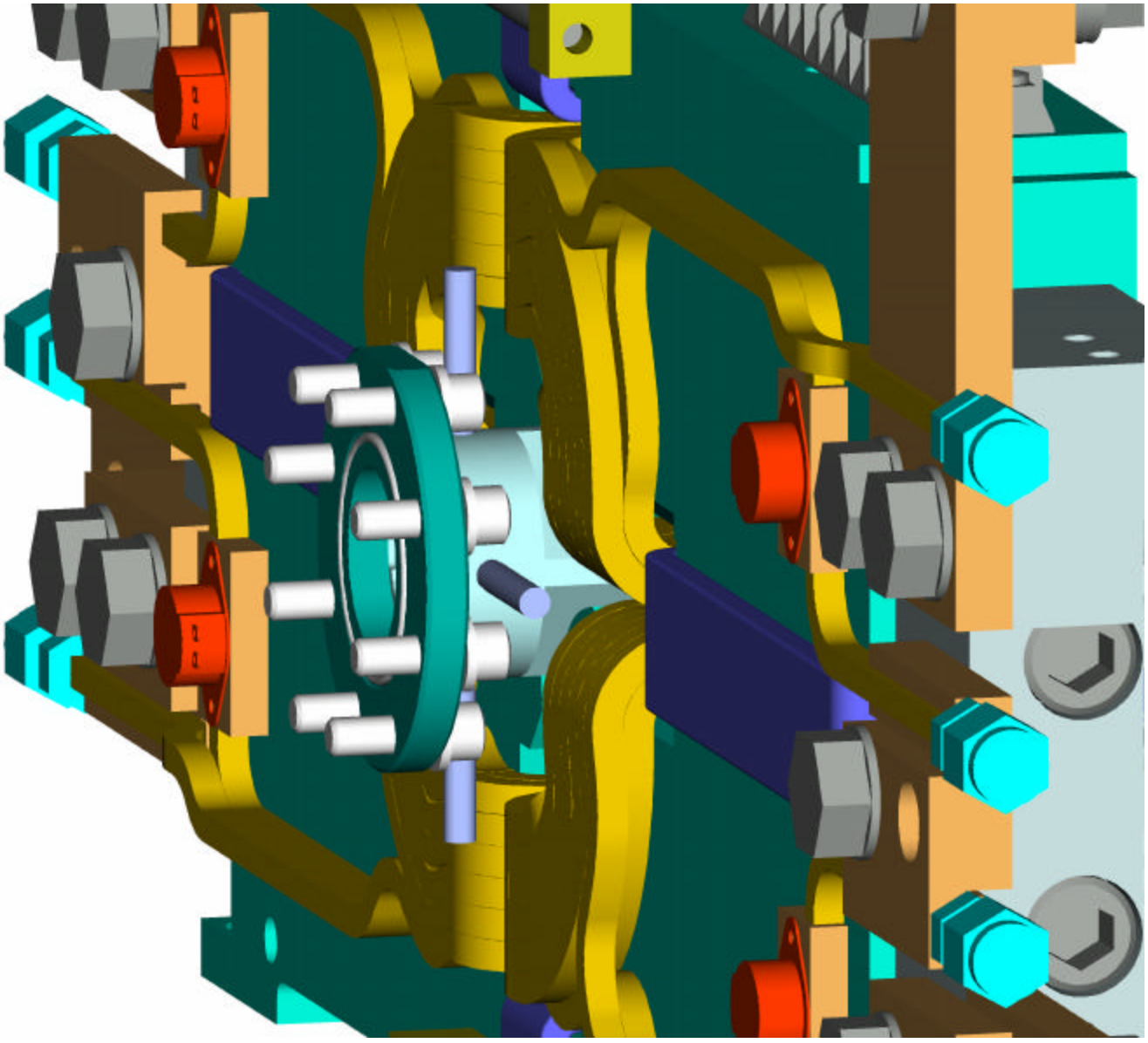
32mm Quadrupole Magnet with
30mm Beam Postion Monitor



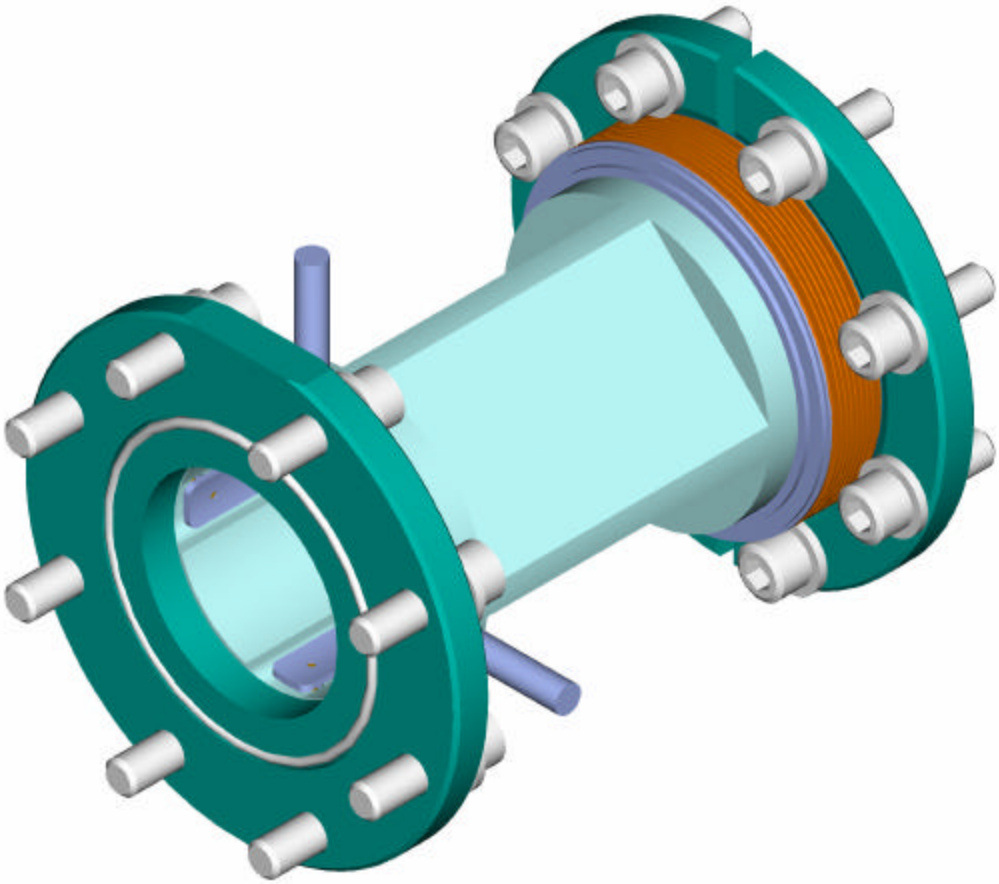
32mm Quadrupole Magnet with
30mm Beam Postion Monitor



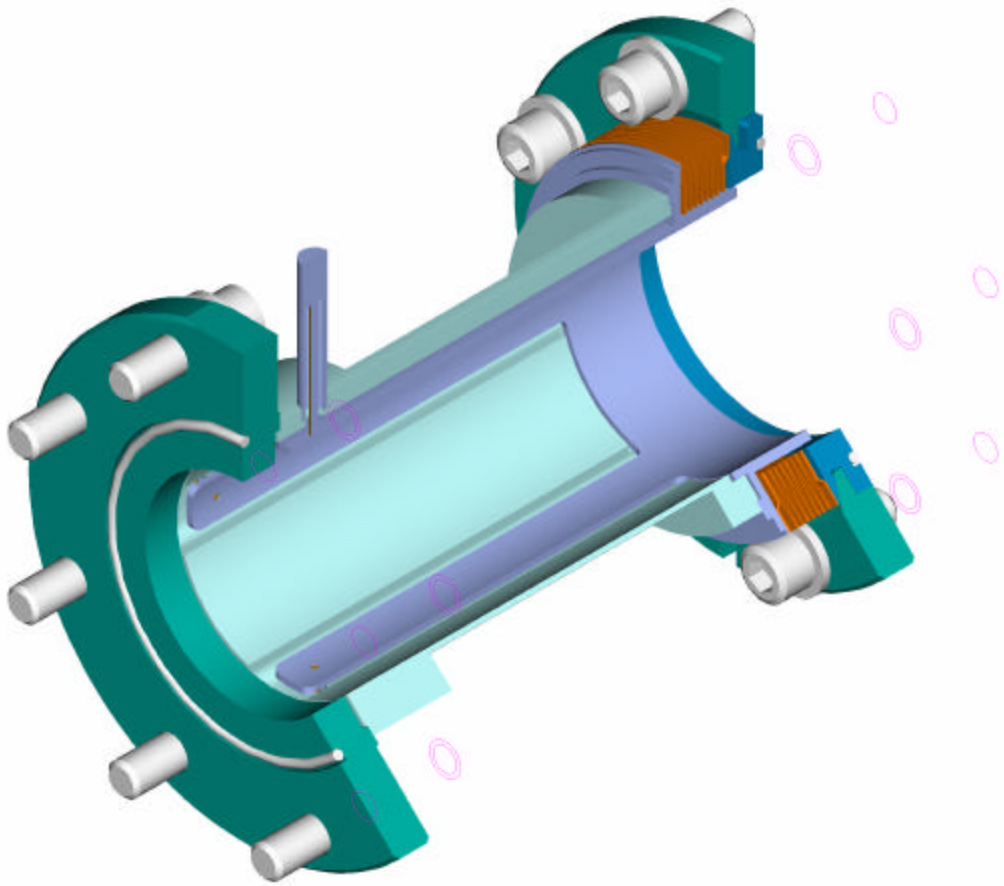
32mm Quadrupole Magnet with
30mm Beam Postion Monitor



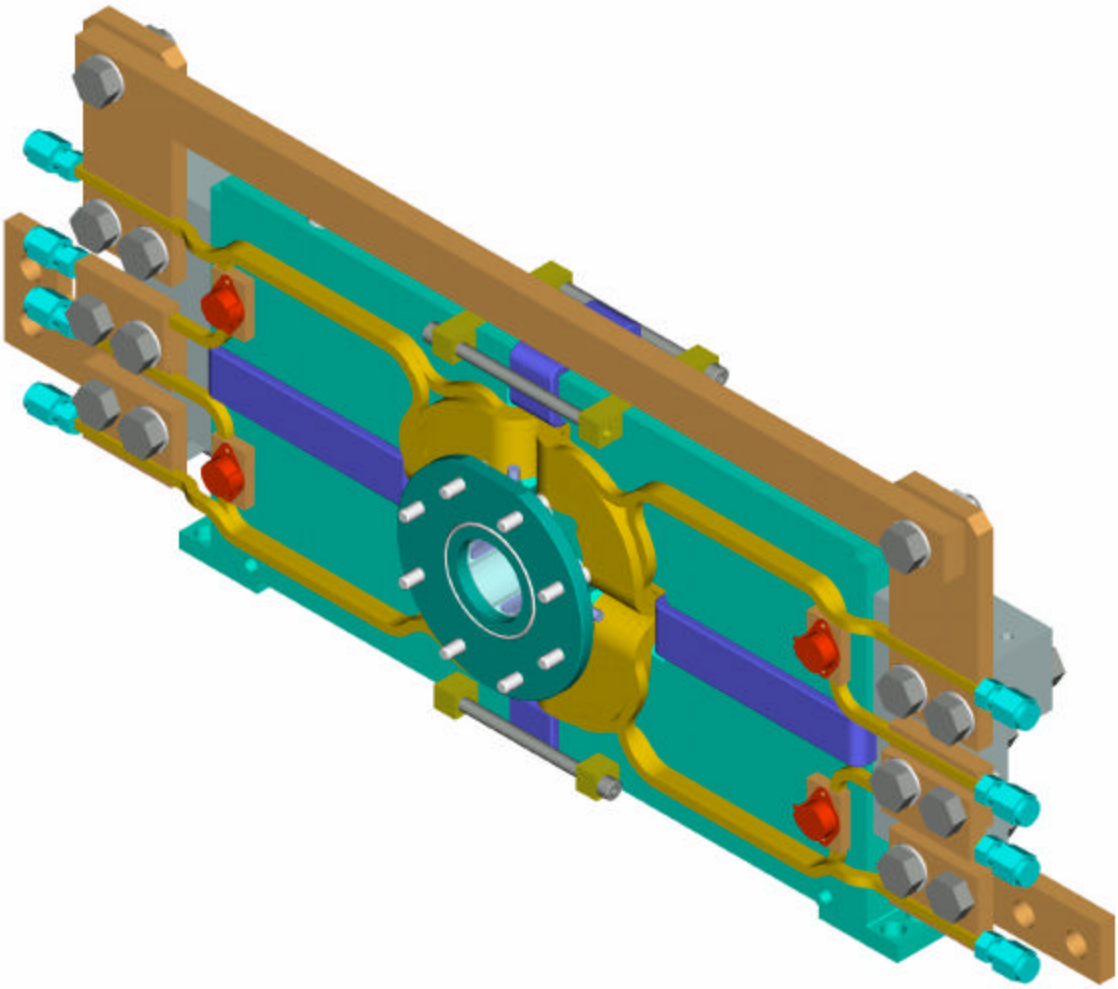
40 mm Beam Position Monitor



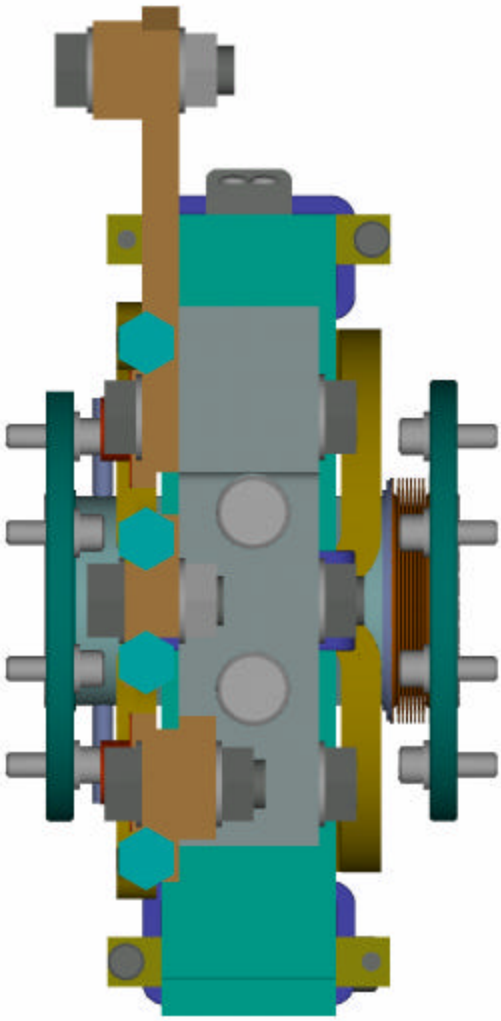
40mm BPM Cross Section View



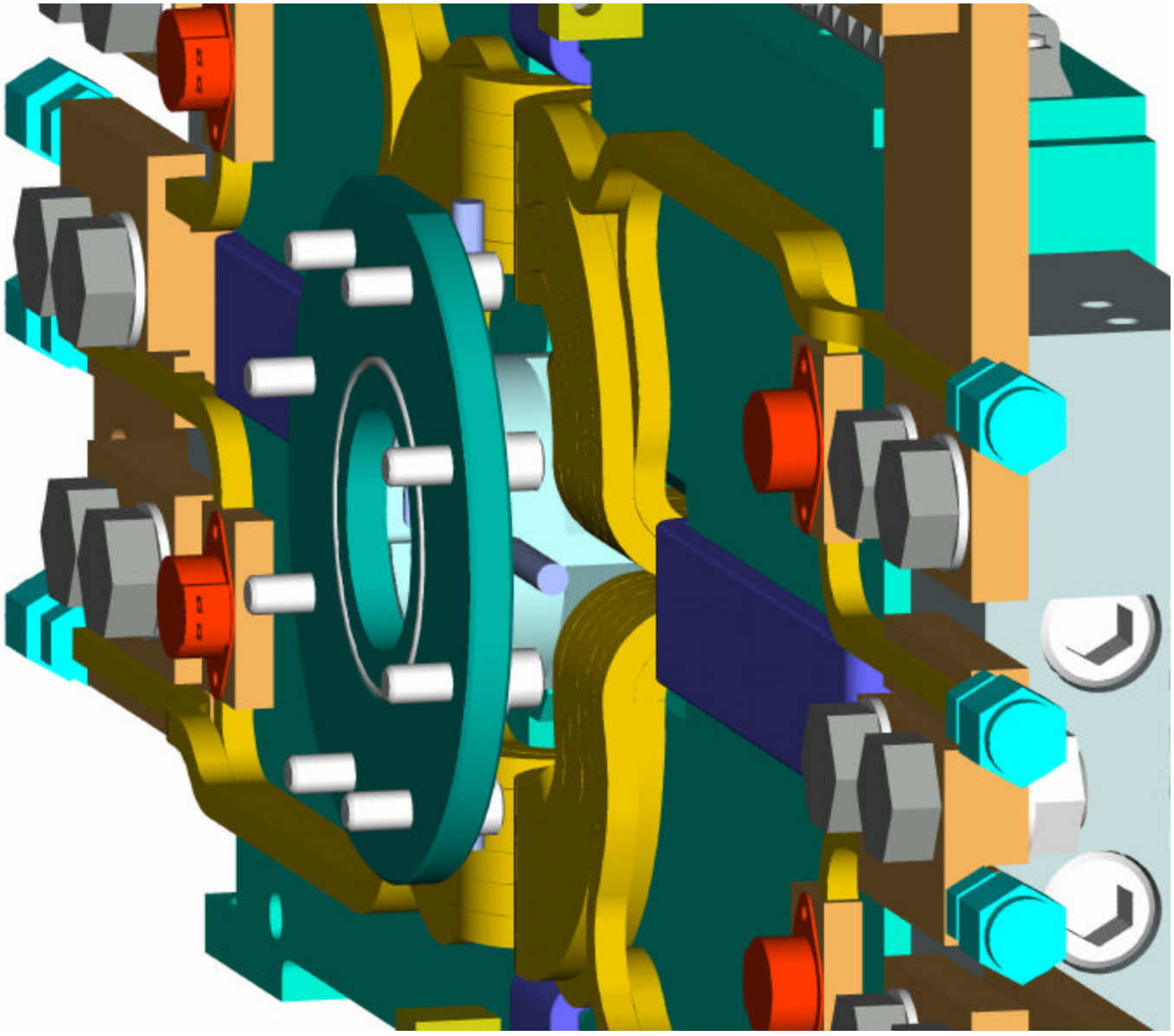
42mm Quadrupole Magnet with
40mm Beam Postion Monitor



42mm Quadrupole Magnet with
40mm Beam Postion Monitor



42mm Quadrupole Magnet with
40mm Beam Postion Monitor

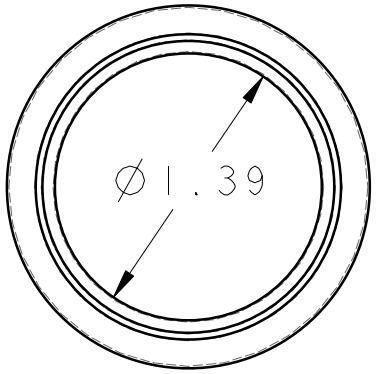


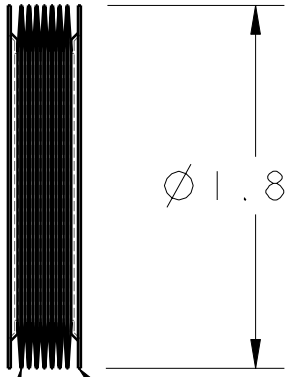
Appendix B

Dwg. No.	Size Rev.
25B170	1B

NOTES

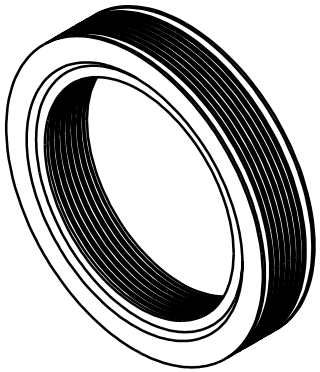
1. STANDARD BELLOWS P/N: 189-139-1/2-B*B* *H= 1.89in
2. DRAWING FOR PRICING QUOTATION ONLY.





189-139 BELLOWS
1/2 SEGMENT.

STYLE "B" END
FLANGE, BOTH SIDES



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Unless Otherwise Noted				Rev	Dwn	Date	Changes
.X±0.1	.XX±0.01	.XXX±0.005	X.X°±0.5	LAWRENCE BERKELEY NATIONAL LABORATORY			
Break Edges .016 Max on Machined Work				University of California - Berkeley			
Remove Burrs, Weld Splatter & Loose Scale				SNS-FES MEBT			
In Accordance With ASME Y14.5M 1994 & B46.1				MECHANICAL SUBSYSTEMS			
Account Number		Finish	-	30 MM BPM BELLOWS			
Date Issued	-	Date Reqd	-				
Number Required		Deliver To		Do Not Scale Prints	Drawing Scale	1/1	
Surface Treatment	-	Identif Method	-	Patent Clear	-	Category Code	FE3313
Drawn By	GOULDING	Date	17-Dec-99	Micro-Filmed	-	Shown on Dwg No.	25B178
Check By	DARYL OSHATZ	Date	4-Jan-00	Design Account	XXXX-XX	Drawing Type	PART

SHEET 1 OF 1

Dwg. No.	Size	Rev
25B170	1	B

Drawing: BPM_30_BELLOWS Type: PART Model: BPM_30_BELLOWS

Dwg. No.	Size Rev.
25B171	1B

NOTES
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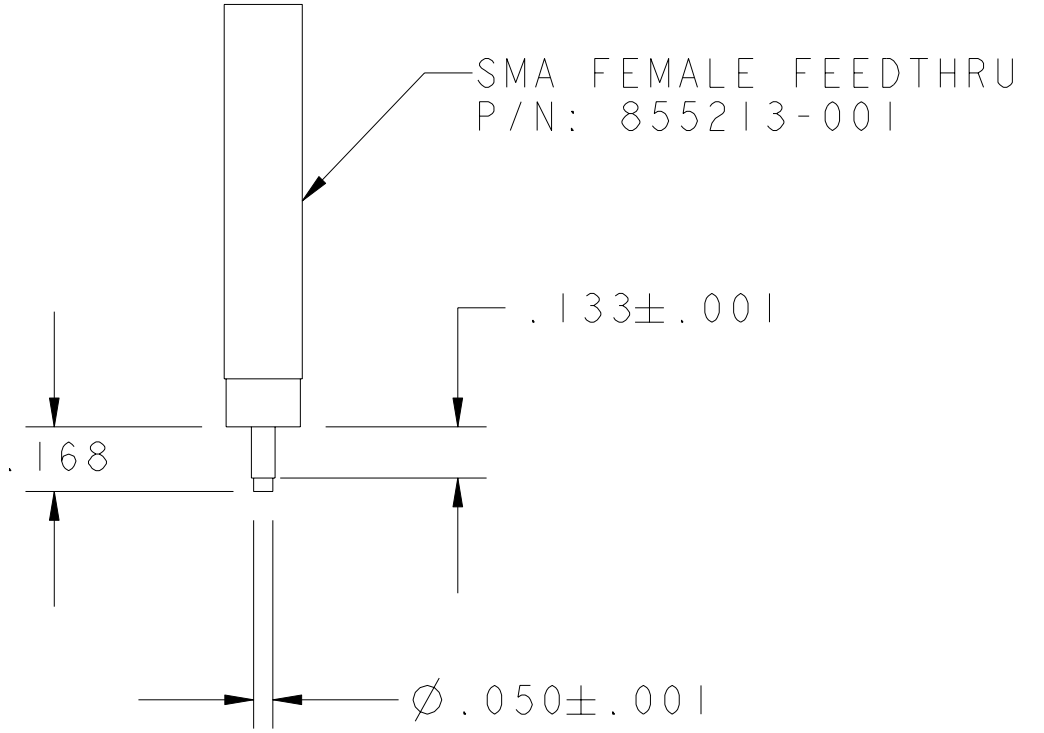
2. DRAWING FOR PRICING QUOTATION ONLY.



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Unless Otherwise Noted		Rev Dwn Date	Changes
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Break Edges .016 Max on Machined Work		University of California - Berkeley	
Remove Burrs, Weld Splatter & Loose Scale		SNS-FES MEBT	
In Accordance With ASME Y14.5M 1994 & B46.1		MECHANICAL SUBSYSTEMS	
Account Number	Finish 125	BPM SMA FEED THRU	
Date Issued -	Date Reqd -		
Number Required	Deliver To	Do Not Scale Prints	Drawing Scale 2/1
Surface Treatment -	Identif Method -	Patent Clear -	Category Code FE3313 SHEET 1 OF 1
Drawn By TREVOR GOULDING	Date 17-Dec-99	Micro-Filmed -	Shown on Dwg No. 25B178, 25B184 Dwg. No. 25B171 Size 1 Rev B
Check By DARYL OSHATZ	Date 1-JAN-00	Design Account XXXX-XX	Drawing Type PART

Drawing: BPM_FEED_THRU_SMA Type: PART Model: BPM_FEED_THRU_SMA

Dwg. No.	Size Rev.
25B172	1B

NOTES

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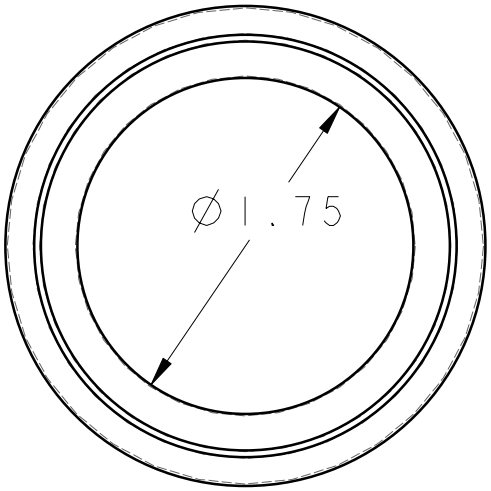
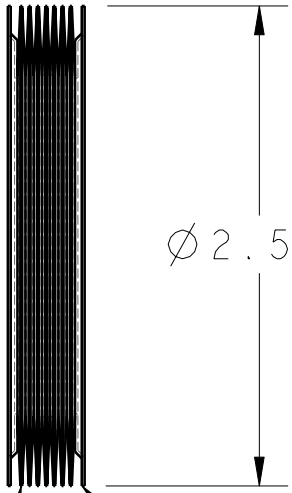
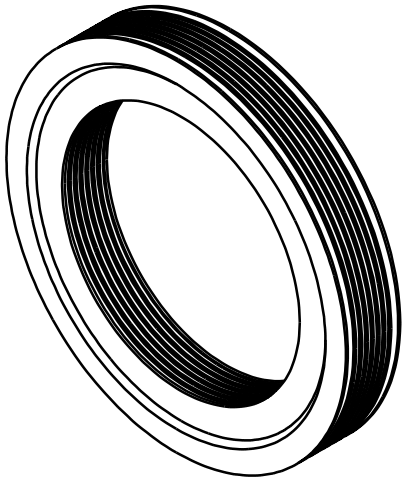
2. DRAWING FOR PRICING QUOTATION ONLY.





250-175 BELLOWS
1/2 SEGMENT.

STYLE "B" END
FLANGE, BOTH SIDES



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Break Edges .016 Max on Machined Work					
Remove Burrs, Weld Splatter & Loose Scale					
In Accordance With ASME Y14.5M 1994 & B46.1					
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Date Issued	-	Date Reqd	-		
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Surface Treatment	-	Identif Method	-		
Drawn By	TREVOR GOULDING	Date	5-Jan-00		
Check By	DARYL OSHATZ	Date	9-Jan-00		

Rev	Dwn	Date	Changes
-	-	-	-

LAWRENCE BERKELEY NATIONAL LABORATORY

University of California - Berkeley

SNS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BPM BELLOWS

Do Not Scale Prints	Drawing Scale 1/1		
Patent Clear -	Category Code FE3313	SHEET 1 OF 1	
Micro-Filmed -	Shown on Dwg No. 25B184	Dwg. No. 25B172 1	Size B	Rev
Design Account XXXX-XX	Drawing Type PART		

Drawing: BPM_40_BELLOWS Type: PART Model: BPM_40_BELLOWS

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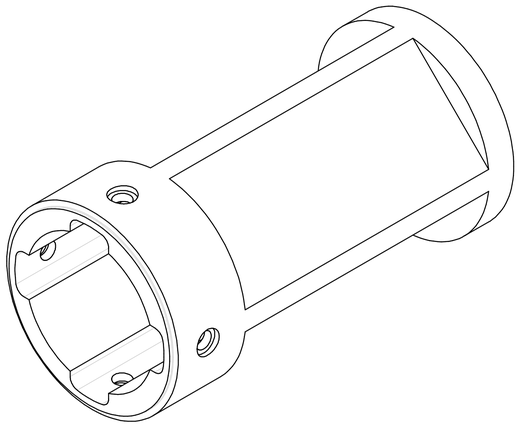
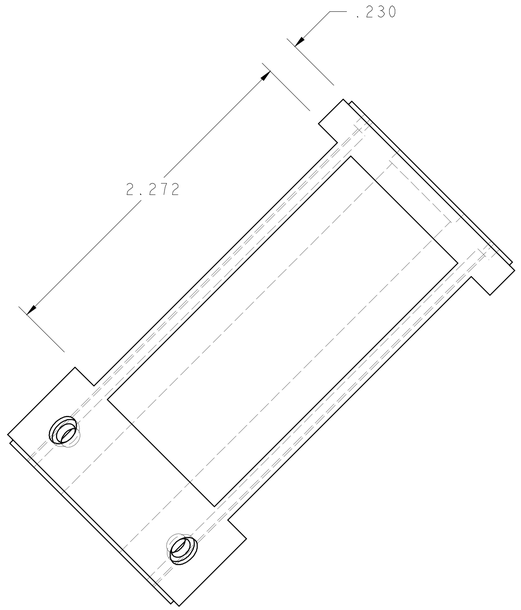
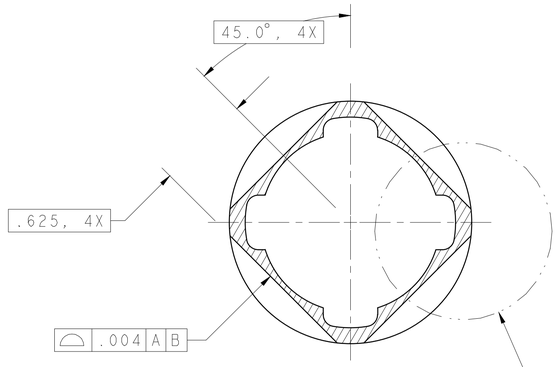
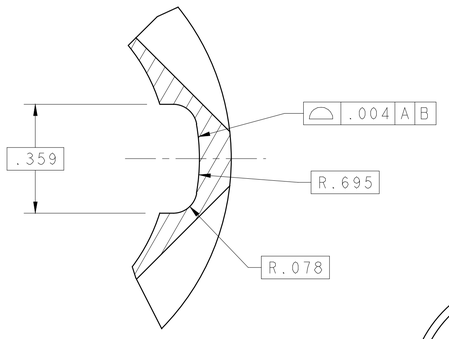


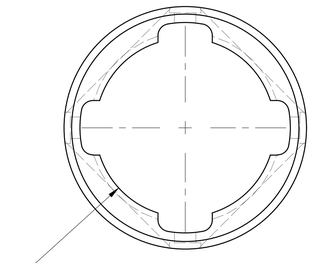


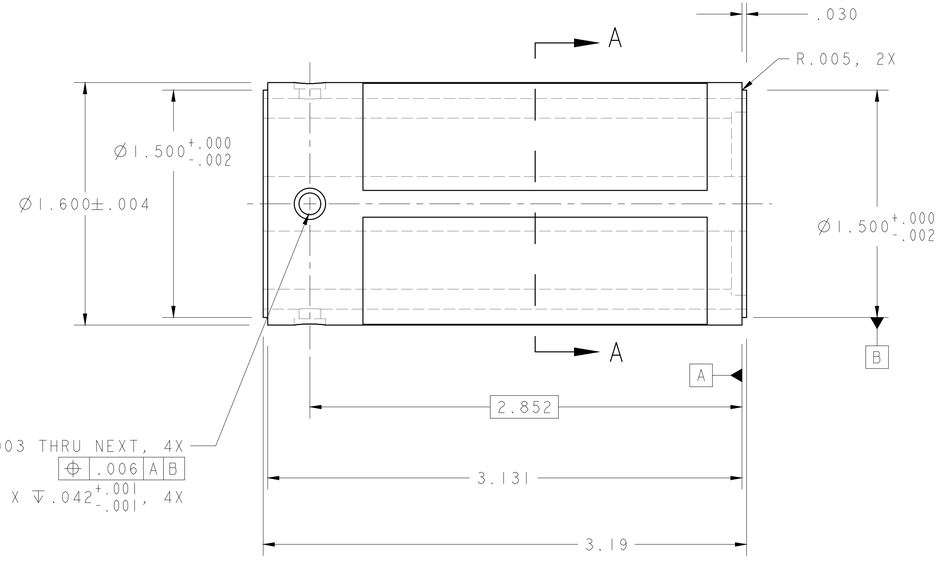


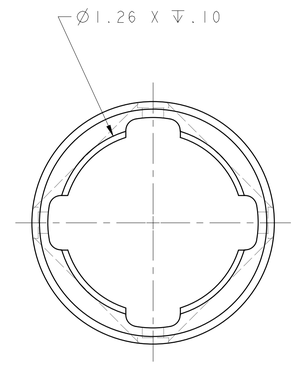
SECTION A - A



DETAIL B
SCALE 4/1
TYPICAL 4 PLACES







25B173 4B

NOTES

1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/26/00	GENERAL CHANGES FOR IMPROVED MANUFACTURABILITY

UNLESS OTHERWISE SPECIFIED

TOLERANCES

X.X±0.1	FRAC.±1/64
X.XX±0.01	Angles±0.5°
X.XXX±0.005	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT	ELECTROPOLISH
IDENT METHOD	-
DWG BY	TREVOR GOULDING DATE 20-Dec-99
CHK BY	DARYL OSHATZ DATE 12-Jan-00

SHOP ORDERS

ACCT NO.	-	SERIAL NO.	-
DATE ISSD	-	DATE REQD	-
NO. REQD	-		
DELIVER TO:	ROOM 71-110 (MS: 71-259)		

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

SNS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BPM BORE TUBE

MICR FLM:	PART	2/1	SHEET 1 OF 1	
PAT CLR:	DWG. TYPE	SCALE	DWG NO.	SIZE / REV
DESIGN ACCT NO.	CATEGORY CODE	SHOWN ON	25B173 4	B
	FE3313	25B178		

Drawing: BPM_30_BORE_TUBE Type: PART Model: BPM_30_BORE_TUBE

25B173 4 B

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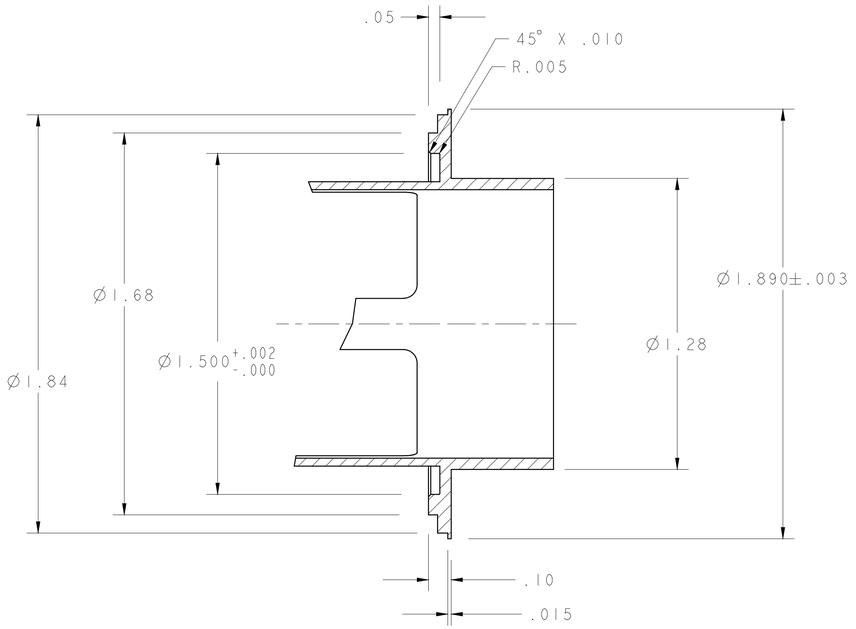
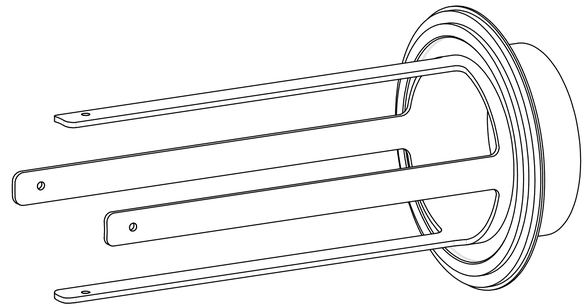
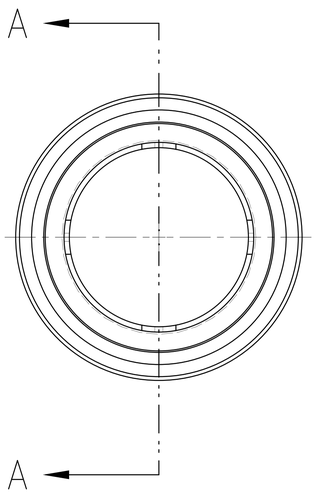
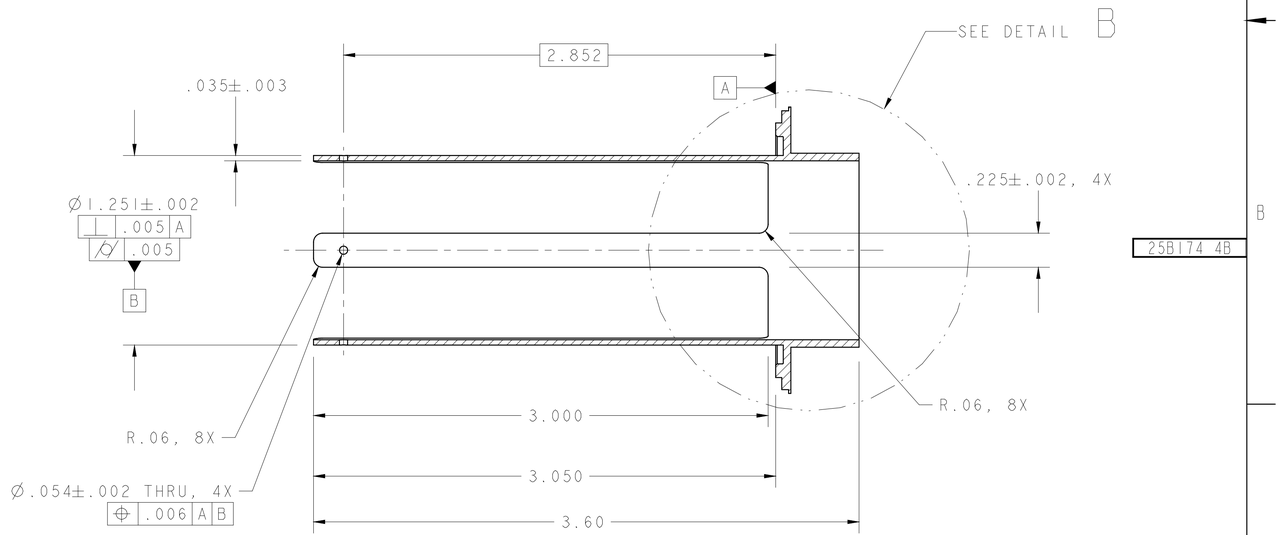




DETAIL B
SCALE 3/1





SECTION A-A

NOTES

1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/26/00	GENERAL CHANGES FOR IMPROVED MANUFACTURABILITY

UNLESS OTHERWISE SPECIFIED

TOLERANCES			
X.X±0.0	FRAC.±1/64		
X.XX±0.01	ANGLE±1/2°		
X.XXX±0.005	FINISH 125		

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT	ELECTROPOLISH
IDENT METHOD	-
DWG BY	TREVOR GOULDING
DATE	20-Dec-99
CHK BY	DARYL OSHATZ
DATE	12-Jan-00

SHOP ORDERS

ACCT NO.	-	SERIAL NO.	-
DATE ISSD	-	DATE REQD	-
DELIVER TO:	ROOM 71-110 (MS:71-259)	NO. REQD	

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

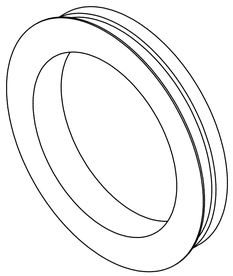
SNS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BPM ELECTRODE SPOOL

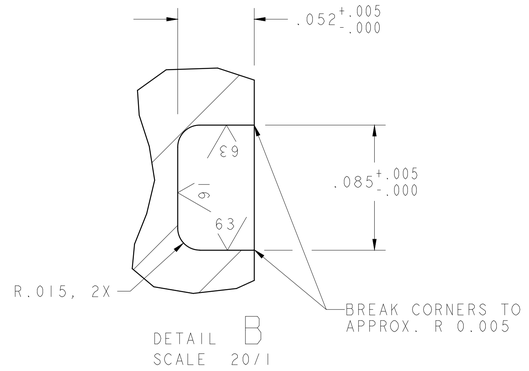
MICR FLM:	PART	2/1	SHEET 1 OF 1	
PAT CLR:	DWG. TYPE	SCALE	DWG NO.	SIZE / REV
DESIGN ACCT NO.	CATEGORY CODE: FE3313	SHOWN ON: 25B178	25B174 4	B

Drawing: BPM_30_STRIPLINE_SPOOL Type: PART Model: BPM_30_STRIPLINE_SPOOL

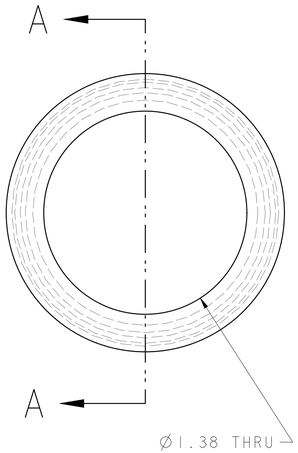
25B174 4 B

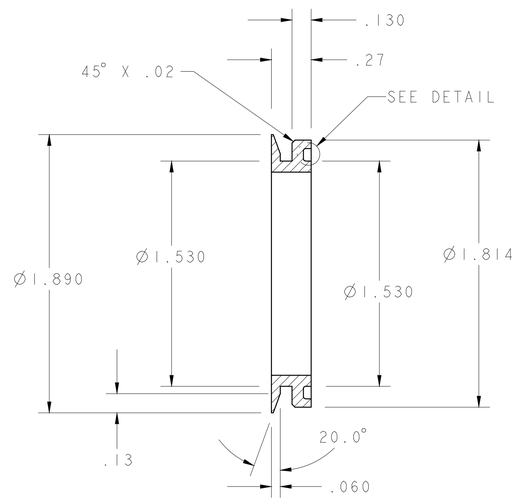
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B175	30 MM BPM BELLOWS SEAL FLANGE	316 STAINLESS STEEL



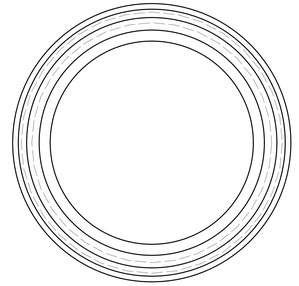


DETAIL B
SCALE 20/1





SECTION A-A



25B175 4B

NOTES

1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	ADD NOTE & UPDATE TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES:
X.X±0.1 FRAC.±1/64
X.XX±0.01 Angles±0.5°
X.XXX±0.005 FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT: ELECTROPOLISH
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE: 16-Dec-99
CHK BY: DARYL OSHATZ DATE: 12-Jan-00

SHOP ORDERS

ACCT NO.: - SERIAL NO.: -
DATE 1550: - DATE REQD: - NO. REQD: -
DELIVER TO: ROOM 71-110 (MS: 71-259)

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

SMS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BPM BELLOWS SEAL FLANGE

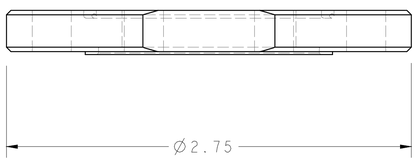
MICR FLM:
PAT CLR:
DESIGN ACCT NO.:

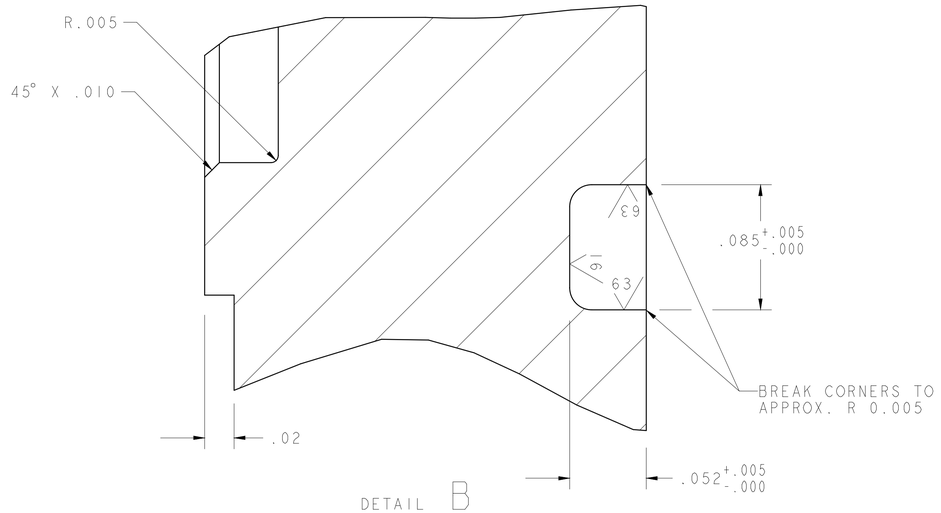
PART DWG. TYPE	2/1 SCALE	SHEET 1 OF 1	
CATEGORY CODE	SHOWN ON	DWG NO.	SIZE / REV
FE3313	25B178	25B175 4	B

Drawing: BPM_30_BELLOWS_SEAL_FLANGE Type: PART Model: BPM_30_BELLOWS_SEAL_FLANGE

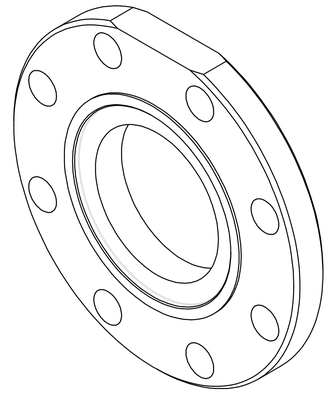
25B175 4 B

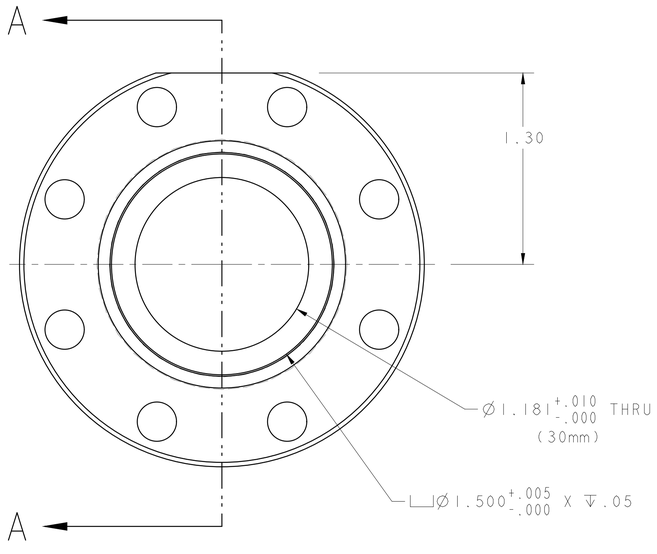
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B176	30 MM BPM FIXED FLANGE	316 STAINLESS STEEL

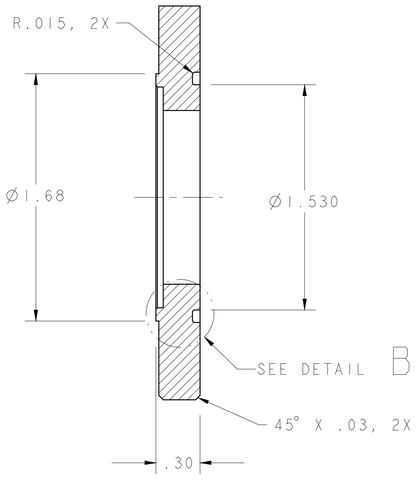




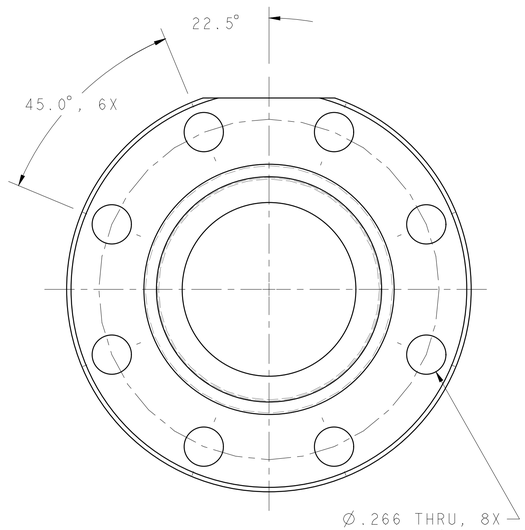
DETAIL B
SCALE 20/1







SECTION A-A



25B176 4B

NOTES
1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK
B			A6	1/27/00	INCREASED C'BORE DEPTH
B			D5	1/27/00	ADDED CHAMFER AND ROUND

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X±0.1 FRAC.±1/64 | X.XX±0.01 Angles±0.5° | X.XXX±0.005 FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

ITEM	PART NO	DESCRIPTION	MATERIAL	REQD	DESIGNER	MAT Location

SURFACE TREATMT: ELECTROPOLISH
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE 16-Dec-99
CHK BY: DARYL OSHATZ DATE 12-Jan-00
SHOP ORDERS
ACCT NO. - SERIAL NO. -
DATE ISSD - DATE REQD - NO. REQD -
DELIVER TO: ROOM 71-110 (MS: 71-259)

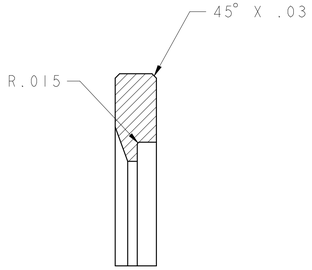
LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BPM FIXED FLANGE

MICR FLM: | PART DWG. TYPE | 2/1 SCALE | SHEET 1 OF 1
PAT CLR: | DESIGN ACCT NO. | CATEGORY CODE FE3313 | SHOWN ON 25B178 | DWG NO. 25B176 4 | SIZE B | REV

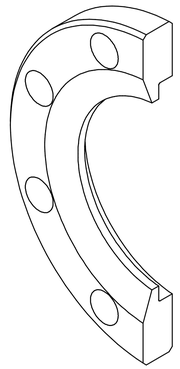
Drawing: BPM_30_FIXED_FLANGE Type: PART Model: BPM_30_FIXED_FLANGE

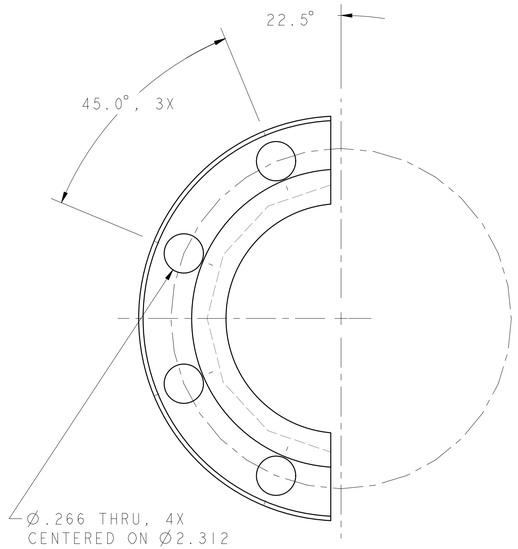
25B176 4 B

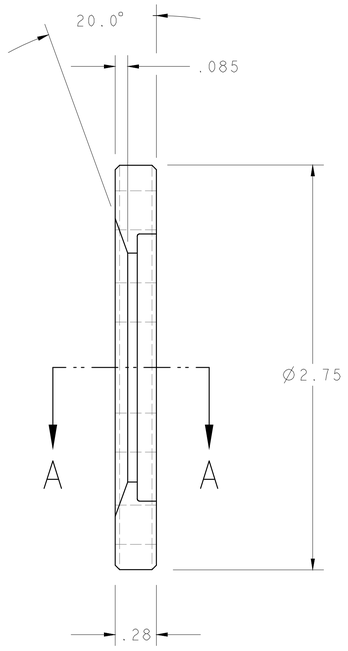
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B177	30 MM BPM SPLIT FLANGE	316 STAINLESS STEEL

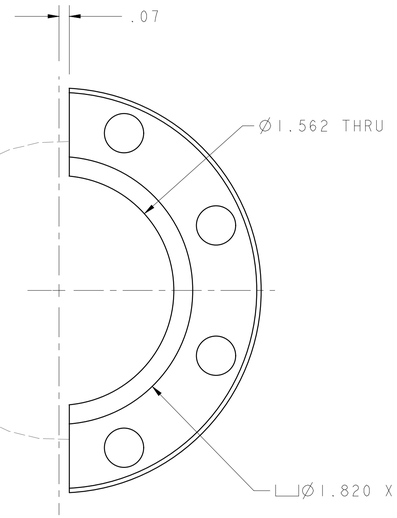


SECTION A - A









25B177 4B

NOTES

1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES

X.X±0.1	FRAC.±1/64
X.XX±0.01	Angles±0.5°
X.XXX±0.005	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

ITEM	PART NO	DESCRIPTION	MATERIAL	REQD	DESIGNER	MAT Location

SURFACE TREATMT: ELECTROPOLISH
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE: 16-Dec-99
CHK BY: DARYL OSHATZ DATE: 12-Jan-00

SHOP ORDERS

ACCT NO. - SERIAL NO. -
DATE ISSD - DATE REQD - NO. REQD -
DELIVER TO: ROOM 71-110 (MS: 71-259)

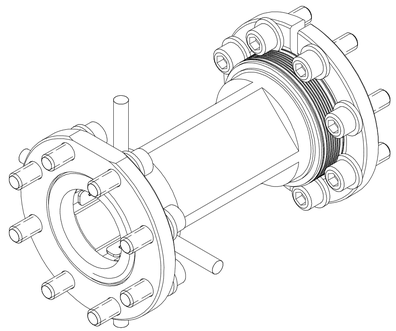
LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

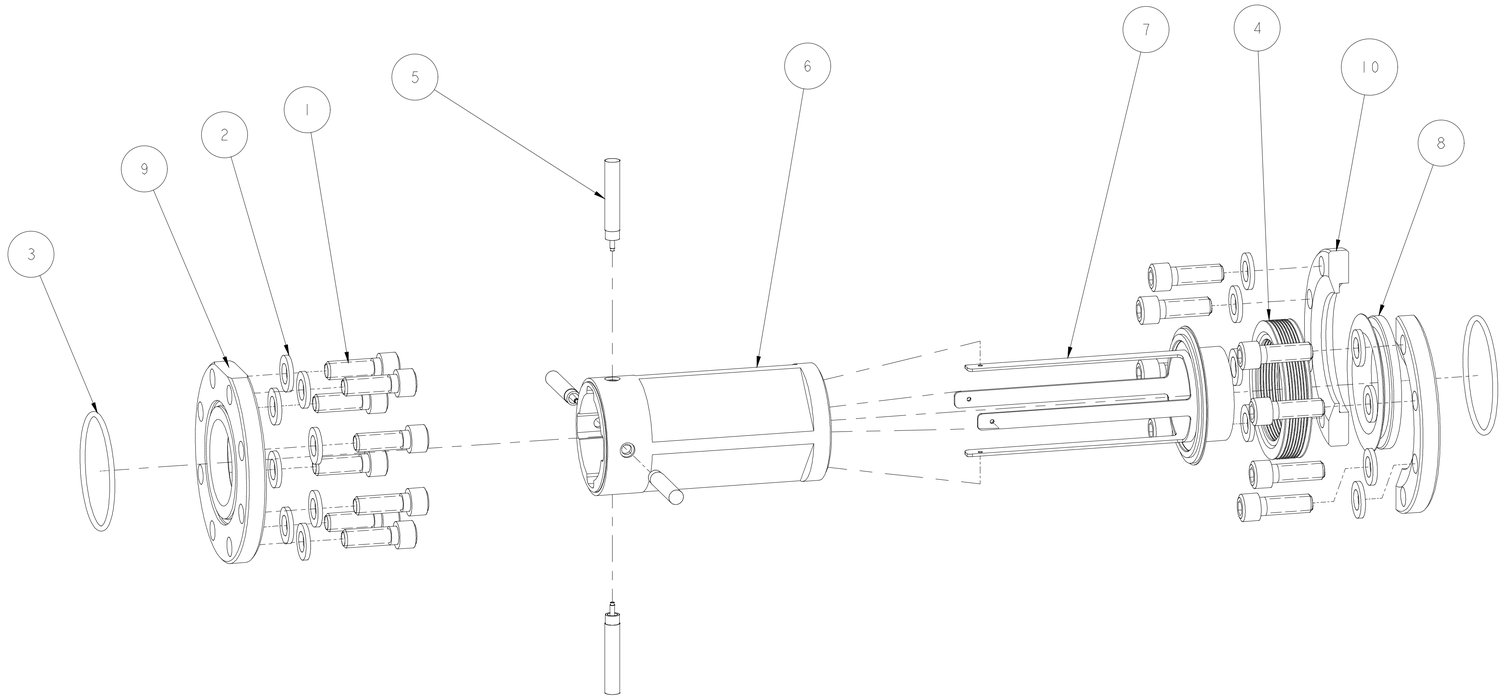
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BPM SPLIT FLANGE

MICR FLM: | PART | 2/1 | SHEET 1 OF 1
PAT CLR: | DWG. TYPE | SCALE | DWG NO. | SIZE | REV
DESIGN ACCT NO.: | CATEGORY CODE | SHOWN ON | 25B177 4 | B
FE3313 | 25B178

Drawing: BPM_30_SPLIT_FLANGE Type: PART Model: BPM_30_SPLIT_FLANGE

25B177 4 B





25B178 4B

ITEM	PART NO	DESCRIPTION	MATERIAL	REQD	MAT Location
10	25B177	30 MM BPM SPLIT FLANGE	316 STAINLESS STEEL	2	
9	25B176	30 MM BPM FIXED FLANGE	316 STAINLESS STEEL	1	
8	25B175	30 MM BPM BELLOWS SEAL FLANGE	316 STAINLESS STEEL	1	
7	25B174	30 MM BPM ELECTRODE SPOOL	316 STAINLESS STEEL	1	
6	25B173	30 MM BPM BORE TUBE	316 STAINLESS STEEL	1	
5	25B171	BPM SMA FEED THRU	-	4	
4	25B170	30 MM BPM BELLOWS	347 STAINLESS STEEL	1	
3		2-029 O-RING SEAL	VITON	2	
2		1/4'' NARROW FLAT WASHER	STAINLESS STEEL	16	
1		1/4-20 X 3/4 SHC SCREW	STAINLESS STEEL	16	

REV	DWG	CHK	ZONE	DATE	CHANGES
B			B1-5	1/27/00	ADDED WELD SIZES TO SYMBOLS
B				1/27/00	CHANGED ORIENTATION OF EXPLODED VIEW
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES

X.X±0.1	FRAC.±1/64
X.XX±0.03	Angles±0.5°
X.XXX±0.010	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT: SEE NOTES (PAGE 2)
IDENT METHOD: TAG
DWG BY: TREVOR GOULDING DATE: 17-Dec-99
CHK BY: DARYL OSHATZ DATE: 12-Jan-00

SHOP ORDERS

ACCT NO. - SERIAL NO. -
DATE ISSD - DATE REQD - NO. REQD
DELIVER TO: ROOM 71-110 (MS 71-259)

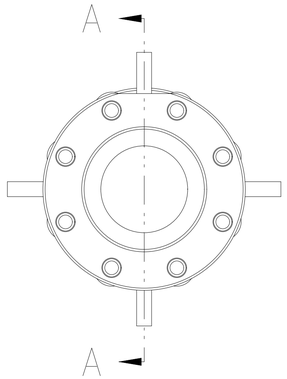
LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

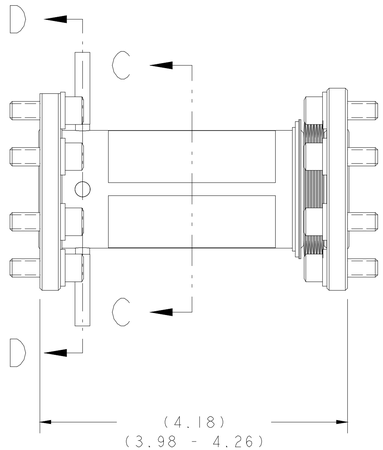
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BEAM POSITION MONITOR

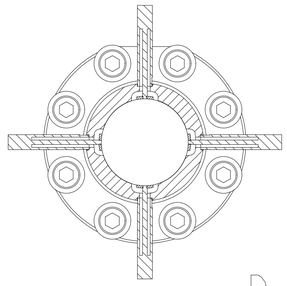
MICR FLM: | ASSEM | 1/1 | SHEET 1 OF 2
PAT CLR: | DWG. TYPE | SCALE | DWG NO. | SIZE | REV
DESIGN ACCT NO: | CATEGORY CODE: FE3313 | SHOWN ON | 25B178 4 | B

Drawing: BPM_30 Type: ASSEM Model: BPM_30

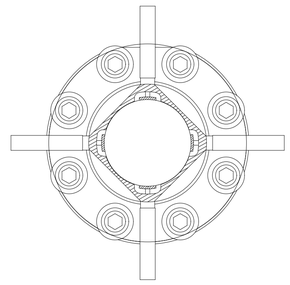
25B178 4 B







SECTION D - D



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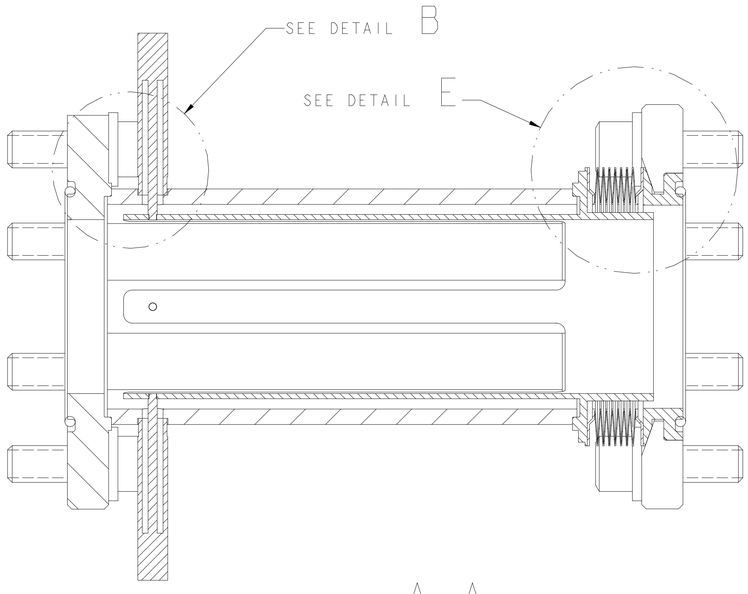
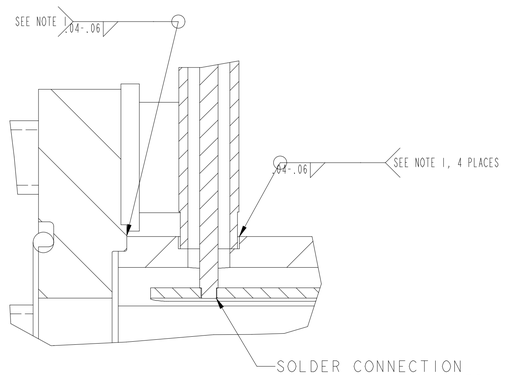
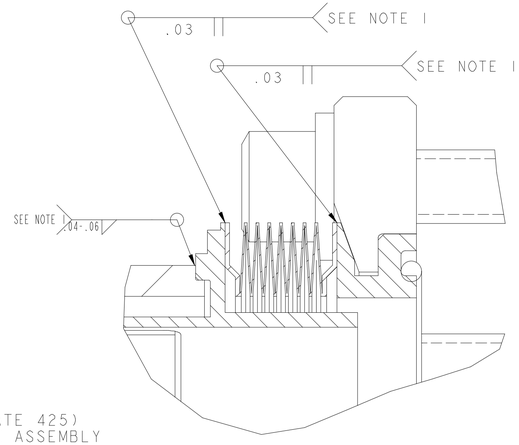


SECTION A - A
SCALE 2/1



DETAIL B
SCALE 4/1



DETAIL E
SCALE 4/1

25B178 4B

NOTES
1. FINISHED PART TO BE VACUUM TIGHT. LEAK RATE NOT TO EXCEED $1x10^{-8}$ torr l/sec. He.
2. ASSEMBLE IN CLEAN ENVIRONMENT. AFTER ASSEMBLY, WRAP TO MAINTAIN CLEANLINESS.

REV	DWG	CHK	ZONE	DATE	CHANGES
B			B1-5	1/27/00	ADDED WELD SIZES TO SYMBOLS
B				1/27/00	CHANGED ORIENTATION OF EXPLODED VIEW
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X±0.1	FRAC.±1/64
	X.XX±0.03	Angles±0.5°
	X.XXX±0.010	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT: SEE NOTES (PAGE 2)
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE 22-Dec-99
CHK BY: DARYL OSHATZ DATE 12-Jan-00

SHOP ORDERS

ACCT NO. - SERIAL NO. -
DATE ISSD - DATE RCVD - NO. RCVD -
DELIVER TO: ROOM 71-110 (MS: 71-259)

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

SMS-FES MEBT
MECHANICAL SUBSYSTEMS
30 MM BEAM POSITION MONITOR

MICR FLM:
PAT CLR:
DESIGN ACCT NO.:

ASSEM DWG. TYPE
FE3313 CATEGORY CODE

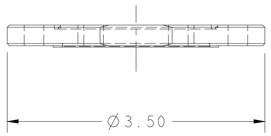
1/1 SCALE
SHOWN ON

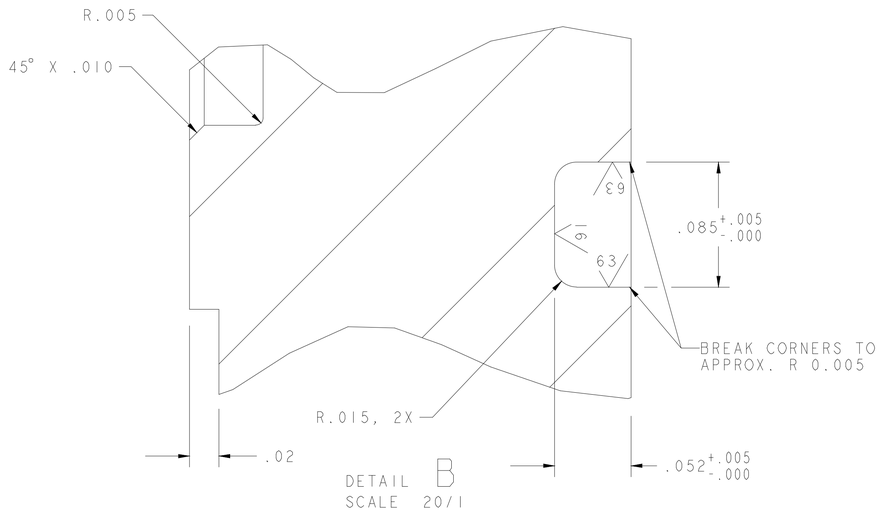
SHEET 2 OF 2
DWG NO. 25B178 4 SIZE B REV

Drawing: BPM_30 Type: ASSEM Model: BPM_30

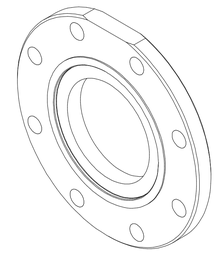
25B178 4 B

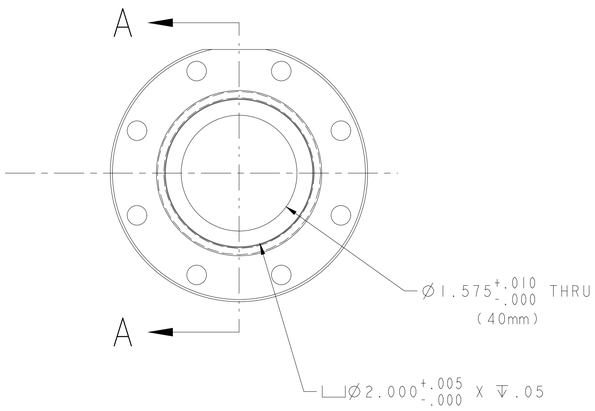
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B179	40 MM BPM FIXED FLANGE	316 STAINLESS STEEL

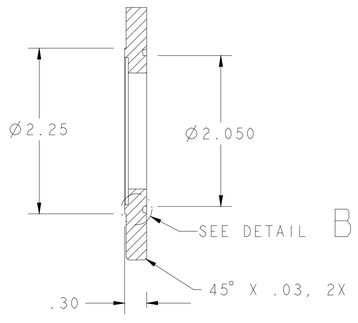




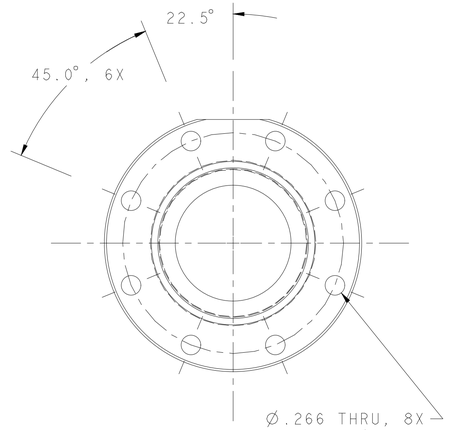
DETAIL B
SCALE 20/1







SECTION A - A



25B179 4B

NOTES

1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK
B			A6	1/27/00	INCREASED C'BORE DEPTH
B			D5	1/27/00	ADDED CHAMFER AND ROUND

UNLESS OTHERWISE SPECIFIED

TOLERANCES:
- X.X±0.1 FRAC.±1/64
- X.XX±0.01 Angles±0.5°
- X.XXX±0.005 FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M 8.8.46.1

SURFACE TREATMT: ELECTROPOLISH
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE 11-Jan-00
CHK BY: DARYL OSHATZ DATE 12-Jan-00

SHOP ORDERS

ACCT NO. -
SERIAL NO. -
DATE 1559 -
DATE REQD -
NO. REQD -
DELIVER TO: ROOM 71-110 (MS: 71-259)

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

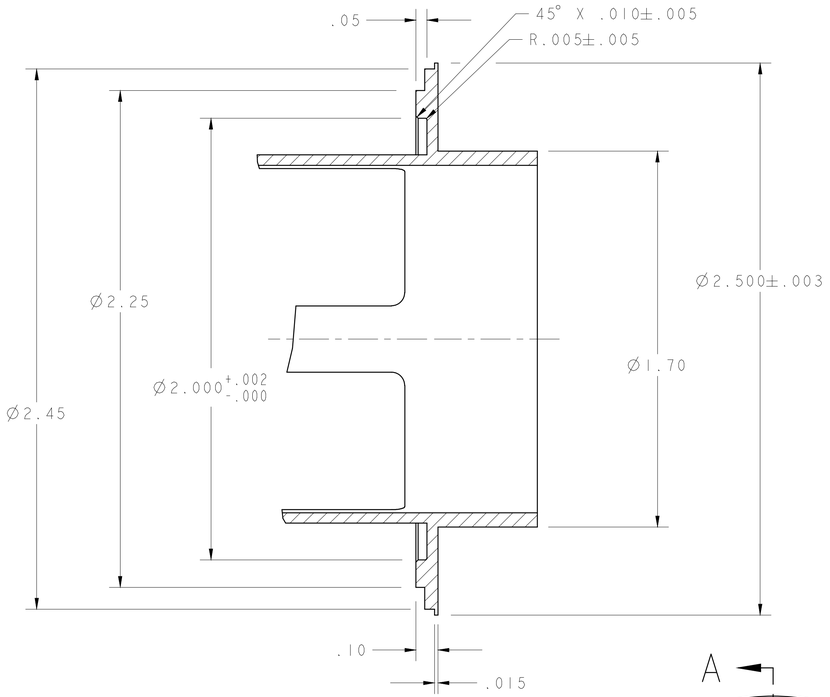
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BPM FIXED FLANGE

MICR FLM:	PART	1/1	SHEET 1 OF 1	
	DWG. TYPE	SCALE	DWG NO.	SIZE / REV
PAT CLR:				
DESIGN ACCT NO.	CATEGORY CODE	SHOWN ON	25B179 4	B
	FE3313	25B184		

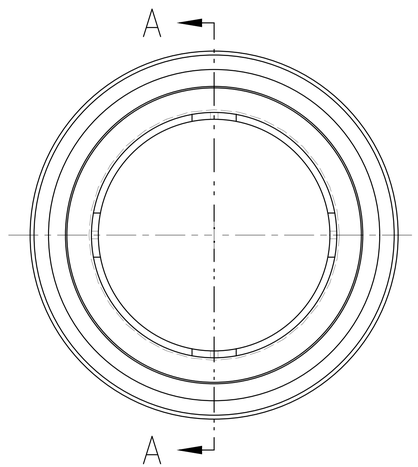
Drawing: BPM_40_FIXED_FLANGE Type: PART Model: BPM_40_FIXED_FLANGE

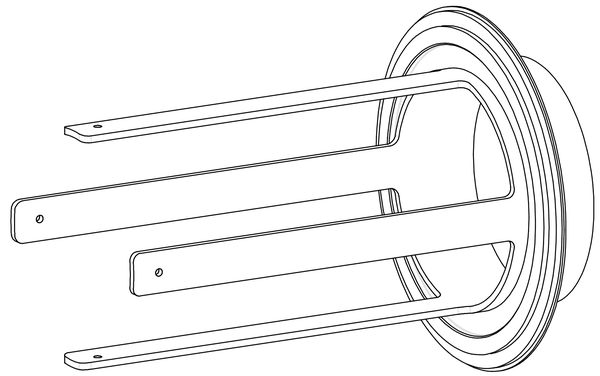
25B179 4 B

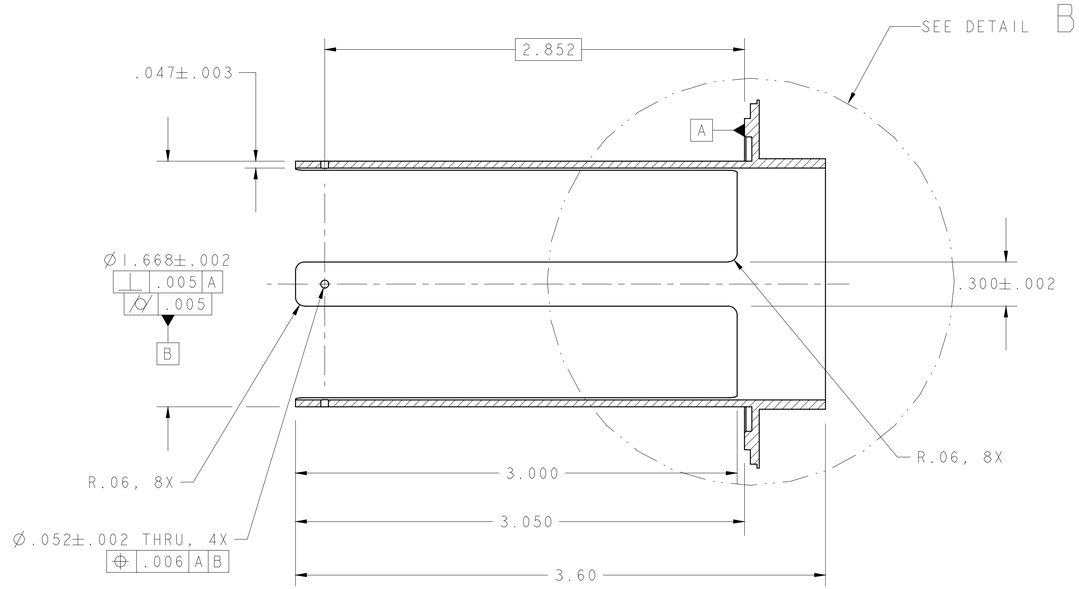
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B180	40 MM BPM ELECTRODE SPOOL	316 STAINLESS STEEL



DETAIL B
SCALE 3/1







SECTION A - A

25B180 4B

NOTES
1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	GENERAL CHANGES FOR IMPROVED MANUFACTURABILITY

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X±0.0	FRAC.±1/64
	X.XX±0.01	Angles±0.5°
	X.XXX±0.005	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT	ELECTROPOLISH
IDENT METHOD	-
DWG BY	TREVOR GOULDING DATE 11-Jan-00
CHK BY	DARYL OSHATZ DATE 12-Jan-00

SHOP ORDERS

ACCT NO.		SERIAL NO.	-
DATE ISSD	-	DATE RCVD	- NO. RCVD
DELIVER TO:	ROOM 71-110 (MS: 71-259)		

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

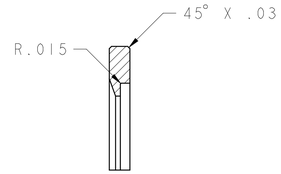
SNS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BPM ELECTRODE SPOOL

MICR FLM:	PART DWG. TYPE	2/1 SCALE	SHEET 1 OF 1	
PAT CLR: DESIGN ACCT NO.	CATEGORY CODE	SHOWN ON	DWG NO.	SIZE / REV
	FE3313	25B184	25B180 4	B

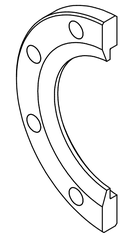
Drawing: BPM_40_STRIPLINE_SPOOL Type: PART Model: BPM_40_STRIPLINE_SPOOL

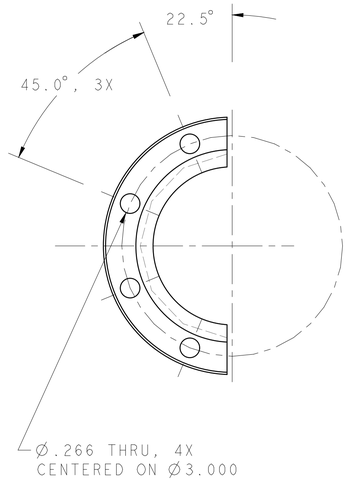
25B180 4 B

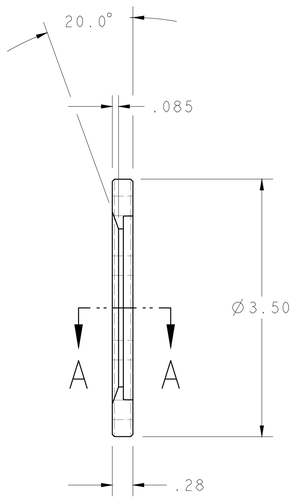
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B181	40 MM BPM SPLIT FLANGE	316 STAINLESS STEEL

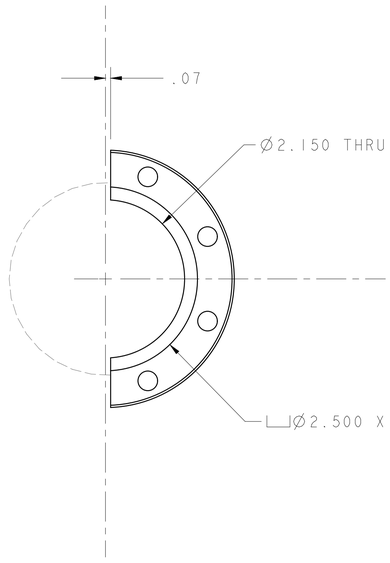


SECTION A - A









25B181 4B

NOTES

1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES: X.X±0.1 FRAC.±1/64 | X.XX±0.01 Angles±0.5° | X.XXX±0.005 FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT: ELECTROPOLISH
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE: 11-Jan-00
CHK BY: DARYL OSHATZ DATE: 12-Jan-00

SHOP ORDERS

ACCT NO. - SERIAL NO. -
DATE ISSD - DATE REQD - NO. REQD -
DELIVER TO: ROOM 71-110 (MS:71-259)

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

SMS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BPM SPLIT FLANGE

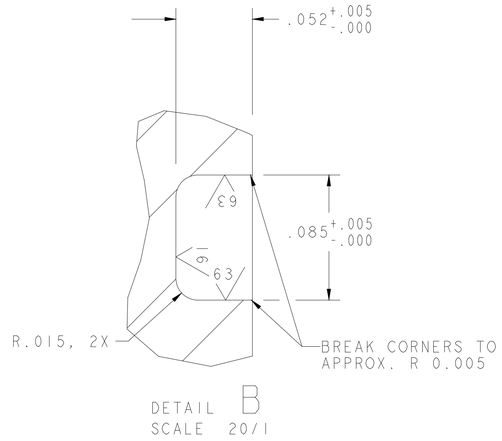
MICR FLM: | PAT CLR: | DESIGN ACCT NO.:

PART	1/1	SHEET 1 OF 1
DWG. TYPE	SCALE	DWG NO. 25B181 4 / SIZE B / REV
CATEGORY CODE FE3313	SHOWN ON 25B184	

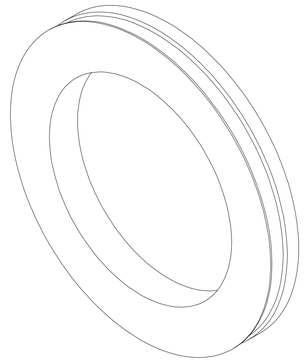
Drawing: BPM_40_SPLIT_FLANGE Type: PART Model: BPM_40_SPLIT_FLANGE

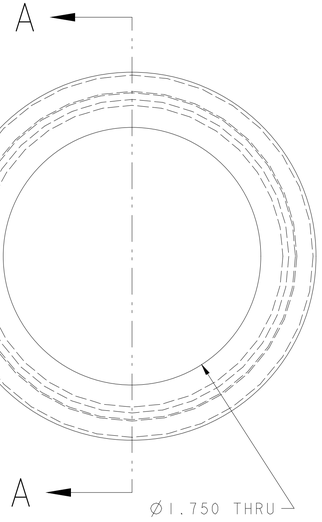
25B181 4 B

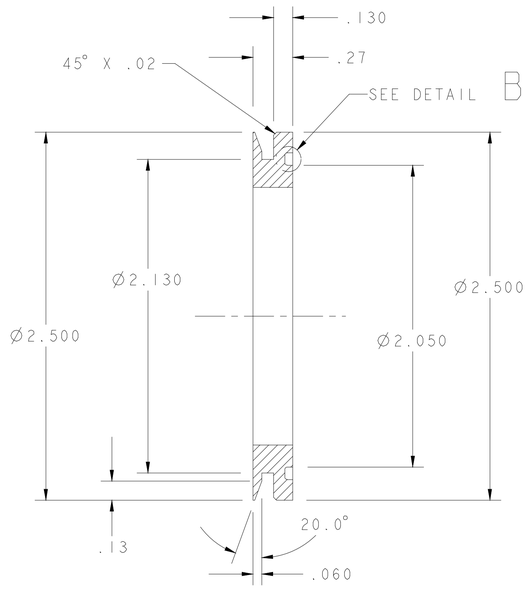
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B182	40 MM BPM BELLOWS SEAL FLANGE	316 STAINLESS STEEL



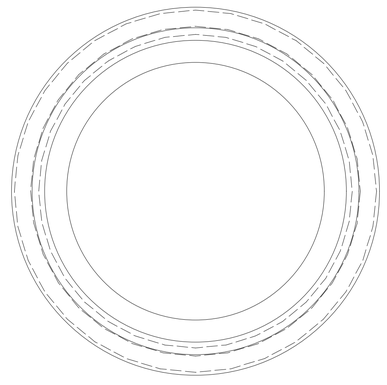
DETAIL B
SCALE 20/1







SECTION A-A



25B182 4B

NOTES
1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES:
- X.X±0.1 — FRAC.±1/64
- X.XX±0.01 — Angles±0.5°
- X.XXX±0.005 — FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT	ELECTROPOLISH
IDENT METHOD	-
DWG BY	TREVOR GOULDING — DATE 11-Jan-00
CHK BY	DARYL OSHATZ — DATE 12-Jan-00

SHOP ORDERS

ACCT NO.	-	SERIAL NO.	-
DATE ISSD	-	DATE REQD	-
NO. REQD	-		
DELIVER TO:	ROOM 71-110 (MS:71-259)		

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

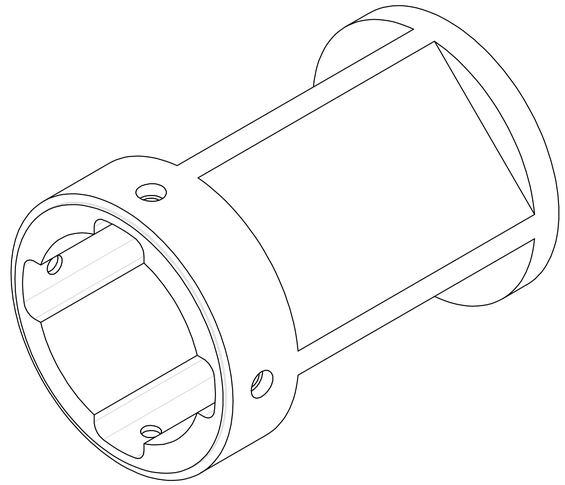
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BPM BELLOWS SEAL FLANGE

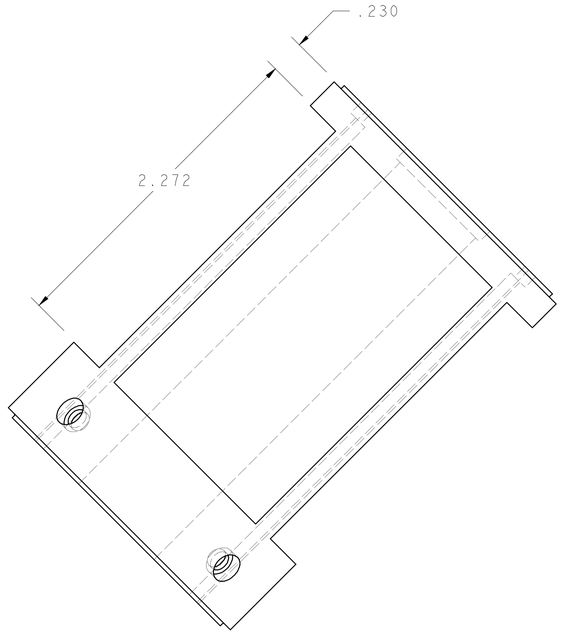
MICR FLM:	PART	2/1	SHEET 1 OF 1	
PAT CLR:	DWG. TYPE	SCALE	DWG NO.	SIZE / REV
DESIGN ACCT NO.	CATEGORY CODE: FE3313	SHOWN ON: 25B184	25B182 4	B

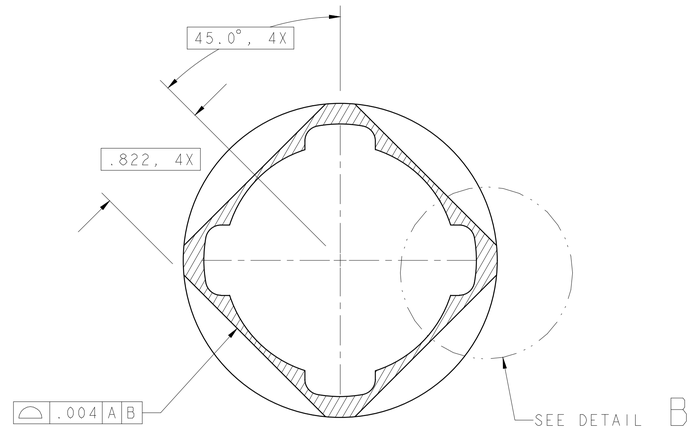
Drawing: BPM_40_BELLOWS_SEAL_FLANGE Type: PART Model: BPM_40_BELLOWS_SEAL_FLANGE

25B182 4 B

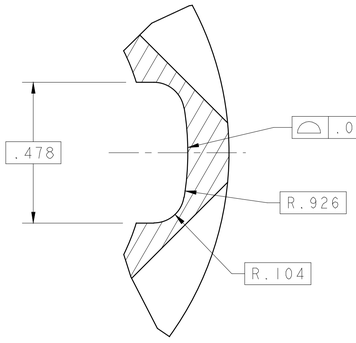
ITEM	REQ	PART NO.	DESCRIPTION	MATERIAL
1		25B183	40 MM BPM BORE TUBE	316 STAINLESS STEEL



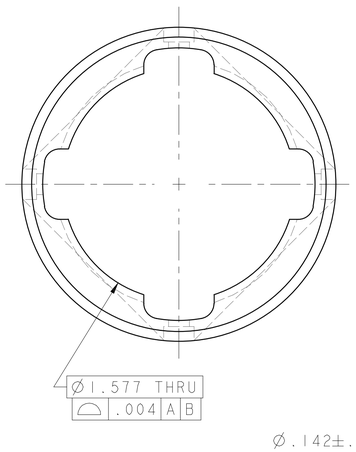


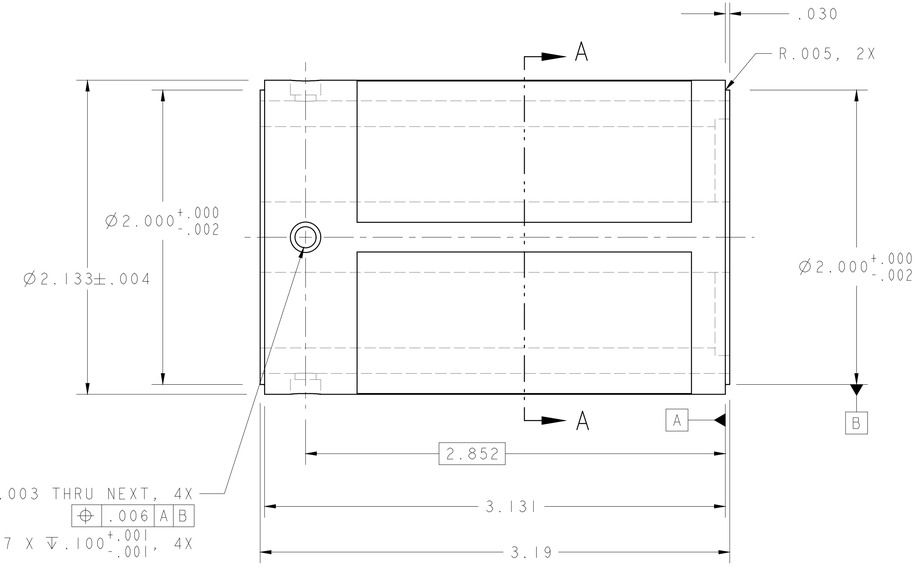


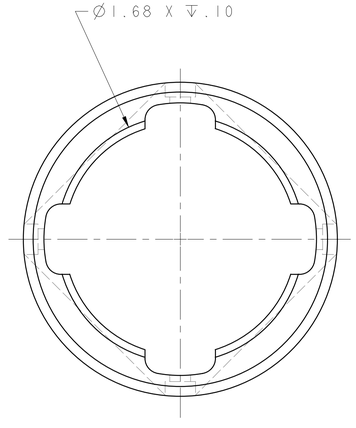
SECTION A - A



DETAIL B
SCALE 4/1
TYPICAL 4 PLACES







25B183 4B

NOTES
1. ULTRA-HIGH VACUUM CLEANING & PACKAGING REQUIRED.

REV	DWG	CHK	ZONE	DATE	CHANGES
B				1/27/00	GENERAL CHANGES FOR IMPROVED MANUFACTURABILITY

UNLESS OTHERWISE SPECIFIED

TOLERANCES		
	X.X±0.1	FRAC.±1/64
	X.XX±0.01	Angles±0.5°
	X.XXX±0.005	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES, 016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT	ELECTROPOLISH
IDENT METHOD	TAG
DWG BY	TREVOR GOULDING DATE 11-Jan-00
CHK BY	DARYL OSHATZ DATE 12-Jan-00

SHOP ORDERS

ACCT NO. -		SERIAL NO. -	
DATE ISSD -	DATE REQD -	NO. REQD -	
DELIVER TO:	ROOM 71-110 (MS: 71-259)		

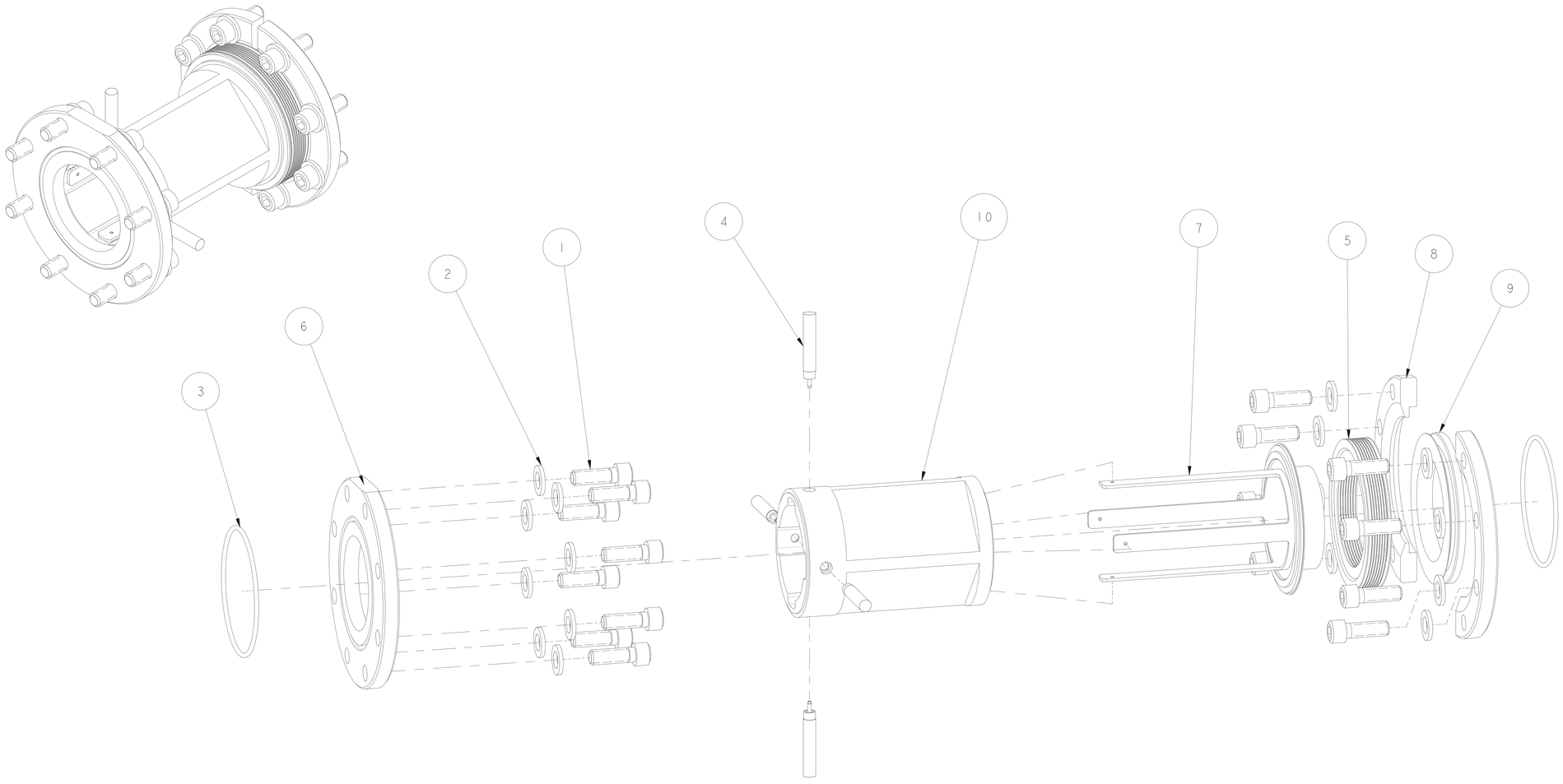
LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

SNS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BPM BORE TUBE

MICR FLM:	PART	2/1	SHEET 1 OF 1	
PAT CLR:	DWG. TYPE	SCALE	DWG NO.	SIZE REV
DESIGN ACCT NO.	CATEGORY CODE: FE3313	SHOWN ON: 25B184	25B183 4	B

Drawing: BPM_40_BORE_TUBE Type: PART Model: BPM_40_BORE_TUBE

25B183 4 B



25B184 4B

ITEM	PART NO	DESCRIPTION	MATERIAL	REQD	MAT Location
10	25B183	40 MM BPM BORE TUBE	316 STAINLESS STEEL	1	
9	25B182	40 MM BPM BELLOWS SEAL FLANGE	316 STAINLESS STEEL	1	
8	25B181	40 MM BPM SPLIT FLANGE	316 STAINLESS STEEL	2	
7	25B180	40 MM BPM ELECTRODE SPOOL	316 STAINLESS STEEL	1	
6	25B179	40 MM BPM FIXED FLANGE	316 STAINLESS STEEL	1	
5	25B172	40 MM BPM BELLOWS	347 STAINLESS STEEL	1	
4	25B171	BPM SMA FEED THRU	-	4	
3	-	2-033 O-RING	VITON	2	
2		1/4'' NARROW FLAT WASHER	STAINLESS STEEL	16	
1		1/4-20 X 3/4 SHC SCREW	STAINLESS STEEL	16	

REV	DWG	CHK	ZONE	DATE	CHANGES
B			B1-5	1/27/00	ADDED WELD SIZES TO SYMBOLS
B				1/27/00	CHANGED ORIENTATION OF EXPLODED VIEW
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED

TOLERANCES

X.X±0.1	FRAC.±1/64
X.XX±0.03	Angles±0.5°
X.XXX±0.010	FINISH 125

DO NOT SCALE PRINT

THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW THREADS 30°
CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .016 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT: SEE NOTES (PAGE 2)
IDENT METHOD: -
DWG BY: TREVOR GOULDING DATE: 11-Jan-00
CHK BY: DARYL OSHATZ DATE: 12-Jan-00

SHOP ORDERS

ACCT NO.: SERIAL NO.: -
DATE ISSD: - DATE REQD: - NO. REQD:
DELIVER TO: ROOM 71-110 (MS: 71-259)

MICR FLM:
PAT CLR:
DESIGN ACCT NO.:

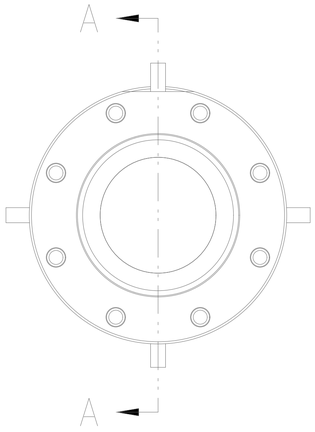
LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY

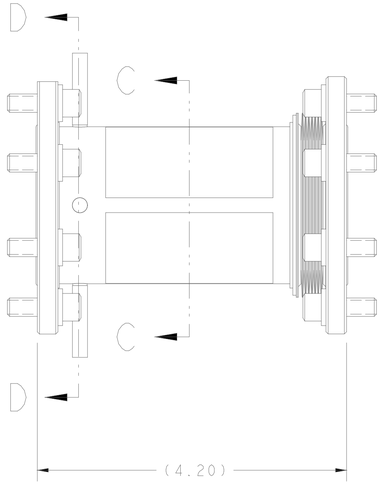
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BEAM POSITION MONITOR

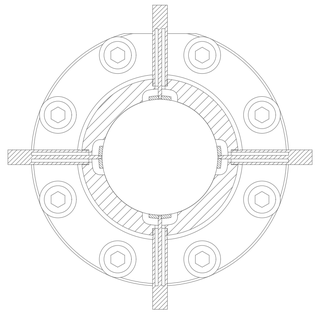
ASSEM (DWG. TYPE) | 1/1 (SCALE) | SHEET 1 OF 2
CATEGORY CODE: FE3313
SHOWN ON:
DWG NO.: 25B184 4 SIZE: B REV

Drawing: BPM_40 Type: ASSEM Model: BPM_40

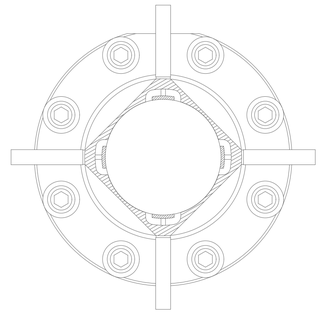
25B184 4 B



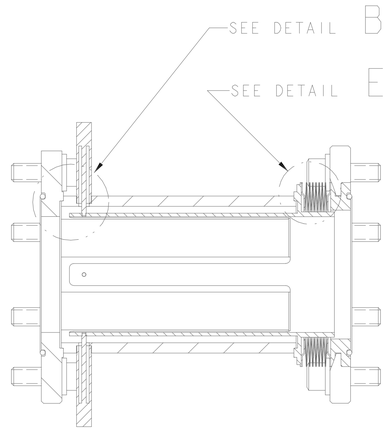




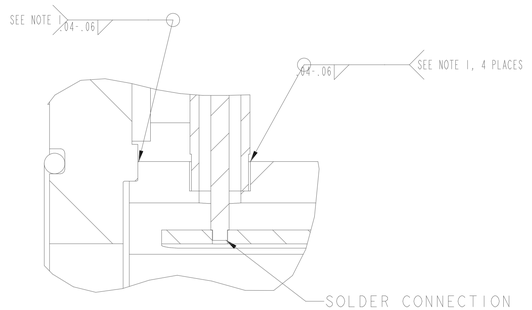
SECTION D - D



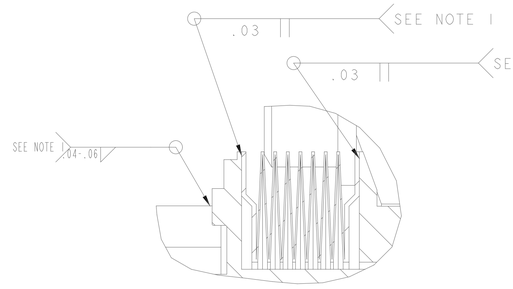
SECTION C - C



SECTION A - A



DETAIL B
SCALE 4/1



DETAIL E
SCALE 4/1

25B184 4B

NOTES
1. FINISHED PART TO BE VACUUM TIGHT. LEAK RATE NOT TO EXCEED $1x10^{-8}$ torr l/sec. He.
2. ASSEMBLE IN CLEAN ENVIRONMENT. AFTER ASSEMBLY, WRAP TO MAINTAIN CLEANLINESS.

REV	DWG	CHK	ZONE	DATE	CHANGES
B			B1-5	1/27/00	ADDED WELD SIZES TO SYMBOLS
B				1/27/00	CHANGED ORIENTATION OF EXPLODED VIEW
B				1/27/00	ADDED NOTE & UPDATED TITLE BLOCK

UNLESS OTHERWISE SPECIFIED
TOLERANCES: X.X±0.1 FRAC.±1/64; X.XX±0.03 Angles±0.5°; X.XXX±0.010 FINISH 125
DO NOT SCALE PRINT
THREADS ARE CLASS 2
CHAMFER ENDS OF ALL SCREW TREADS 30° CUT ROUND, 1.5 THREAD RELIEF ON MACHINED THREADS
BREAK EDGES .015 MAX. ON MACHINED WORK
REMOVE BURRS, WELD SPLATTER & LOOSE SCALE
IN ACCORDANCE WITH ASME Y14.5M & B46.1

SURFACE TREATMT SEE NOTES (PAGE 2)
IDENT METHOD -
DWG BY TREVOR GOULDING DATE 16-Jan-00
CHK BY DARYL OSHATZ DATE 12-Jan-00
SHOP ORDERS
ACCT NO. &shop_acct SERIAL NO. -
DATE ISSD - DATE REQD - NO. REQD -
DELIVER TO: ROOM 71-110 (MS: 71-259)

LAWRENCE BERKELEY NATIONAL LABORATORY
UNIVERSITY OF CALIFORNIA-BERKELEY
SMS-FES MEBT
MECHANICAL SUBSYSTEMS
40 MM BEAM POSITION MONITOR

MICR FLM: | PAT CLR: | DESIGN ACCT NO.
ASSEM DWG. TYPE | 1/1 SCALE | SHEET 2 OF 2 SHOWN ON
CATEGORY CODE FE3313
DWG NO. 25B184 4 SIZE B REV

Drawing: BPM_40 Type: ASSEM Model: BPM_40

25B184 4 B

Appendix C

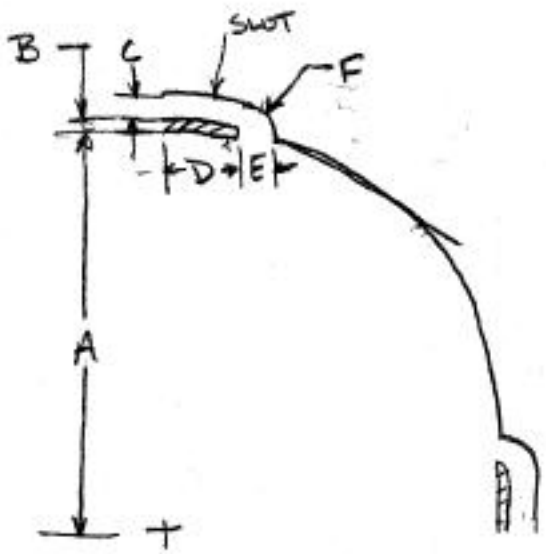
TREVOR GOULDING BPM DESIGN 1/6/00

TOLERANCE STACK UP ANALYSIS

ASSUMPTIONS:

1. THE DIMENSIONS OF THE ELECTRODE AND THE SLOT MUST STAY WITHIN 5% OF NOMINAL (PER RECOMMENDATION OF LARRY DOOLITTLE. (SEE
2. RSS (ROOT SUM SQUARED) METHOD WILL BE USED FOR ALL TOLERANCE STACK UP ANALYSIS

ELECTRODE AND SLOT GEOMETRY



NOT TO SCALE

DIMENSION MAINTAIN SOLID RESISTANCE (PROVIDED BY LARRY DOOLITTLE)

DIMENSIONS IN MM.

A → 15.00
B → 0.889
C → 1.761
D → 2.862
E → 1.703
F → 1.983

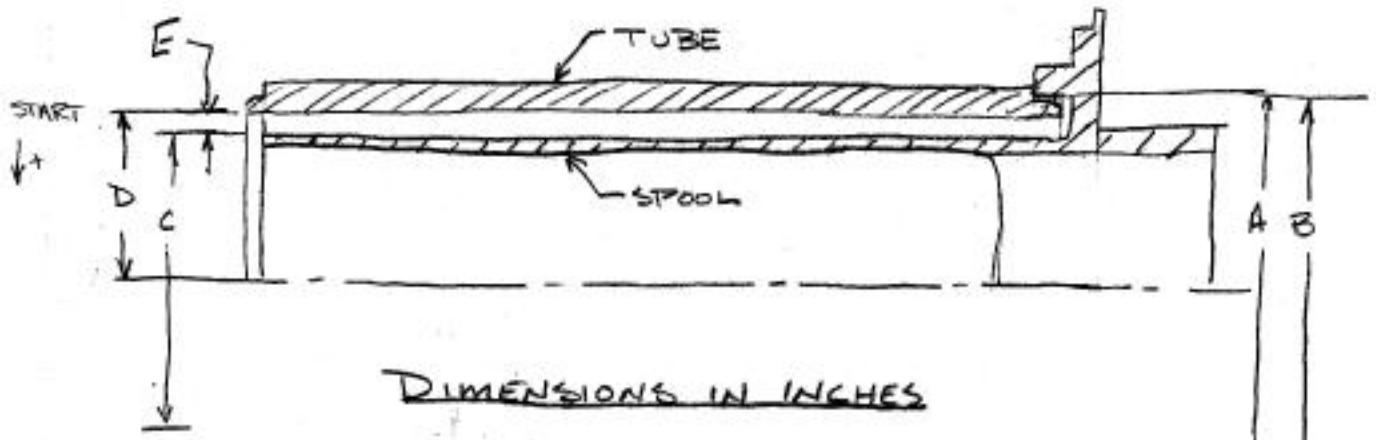
DIMENSION C IS CRITICAL AT ±5% OF NOMINAL

1.761 ± 0.088 → 0.069 ± 0.0035 in

TOLERANCE STACKS MUST BE

≤ ± 0.003 in ←

TREVOR GOULDING BPM DESIGN 1/6/00



DIMENSIONS IN INCHES

A (TUBE DIA)	$1.500^{+0.000}_{-0.002}$	$\rightarrow 1.499 \pm 0.001$
B (SPOOL DIA)	$1.500^{+0.002}_{-0.000}$	$\rightarrow 1.501 \pm 0.001$
C (SPOOL DIA)	1.251 ± 0.002	
D (TUBE RAD)	0.695 ± 0.002	
E (GAP)		

$$E_{NOM} = D_{NOM} - \frac{A_{NOM}}{2} + \frac{B_{NOM}}{2} - \frac{C_{NOM}}{2} = 0.695 - \frac{1.500}{2} + \frac{1.500}{2} - \frac{1.251}{2} = 0.070$$

$$T_E = \sqrt{T_D^2 + (1/2 T_A)^2 + (1/2 T_B)^2 + (1/2 T_C)^2} = \sqrt{(0.002)^2 + (1/2 \cdot 0.001)^2 + (1/2 \cdot 0.001)^2 + (1/2 \cdot 002)^2} = 0.003$$

$E = 0.070 \pm 0.003$

DIMENSIONS IN INCHES

A (TUBE O.D.)	1.600	± 0.004
B (FEED THRU COND)	0.133	± 0.001
C (C'BORE)	0.042	± 0.001
D (TUBE SLOT RAD)	0.695	± 0.002
E (GAP)		

$$E_{NOM} = B_{NOM} + C_{NOM} - \frac{A_{NOM}}{2} + D_{NOM} = 0.133 + 0.042 - \frac{1.600}{2} + .695 = 0.070$$

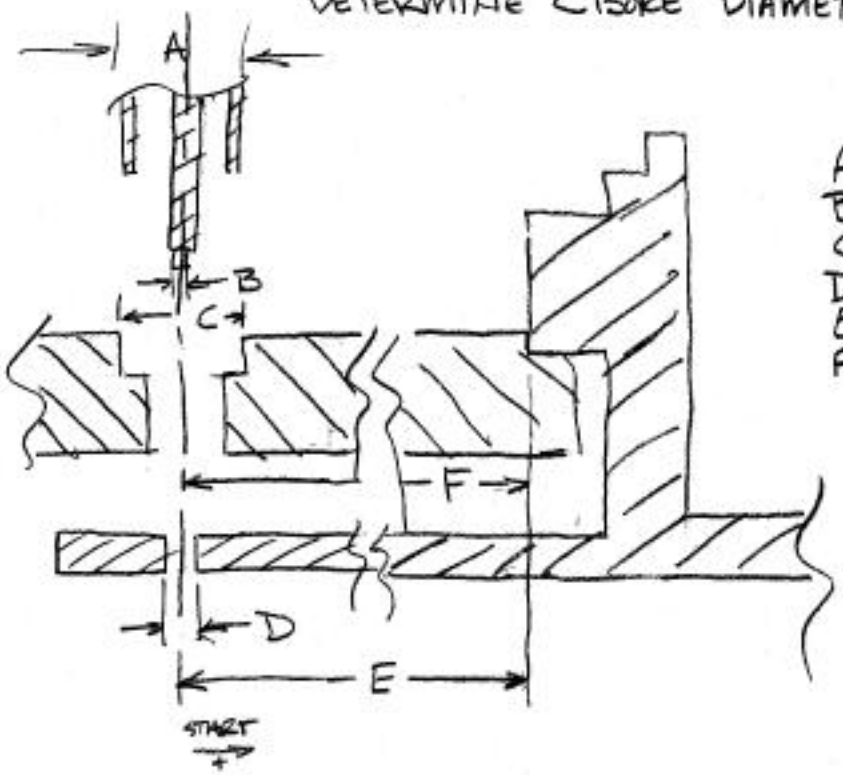
$$T_E = \sqrt{T_B^2 + T_C^2 + (1/2 T_A)^2 + T_D^2} = \sqrt{0.001^2 + 0.001^2 + (1/2 \cdot 0.004)^2 + 0.002^2} = 0.003$$

$E = 0.070 \pm 0.003$

TREVOR GOULDING BPM DESIGN 1/6/00

DETERMINE C'BORE DIAMETER & TOLERANCE

DIMENSION IN INCHES



A	(FEEDTHRU)	0.199 ± 0.001
B	(FEEDTHRU)	0.050 ± 0.001
C	(C'BORE)	
D	(SPOOL HOLE)	0.059 ± 0.002
E	(SPOOL HOLE)	2.852 ± 0.005
F	(C'BORE)	2.852 ± 0.003

A MINIMUN GAP OF 0.005" ARDUND SHOULD BE MAINTAINED BETWEEN THE C'BORE AND THE FEED-THRU

$$C_{min} = 2(F_{NOM} - E_{NOM} + \tfrac{1}{2}D_{MIN} - \tfrac{1}{2}B_{MAX} + \tfrac{1}{2}A_{MIN}) + 0.005$$

$$= 2(F_{NOM} - E_{NOM}) + D_{MIN} - B_{MAX} + A_{MIN} + 0.005$$

$$= 2(2.852 - 2.852) + 0.052 - 0.051 + 0.193 + 0.005$$

$$= 0.199$$

$$C_{max} = 2(F_{max} - E_{min} + \tfrac{1}{2}D_{max} - \tfrac{1}{2}B_{min} + \tfrac{1}{2}A_{max})$$

$$= 2(F_{max} - E_{min}) + D_{max} - B_{min} + A_{max}$$

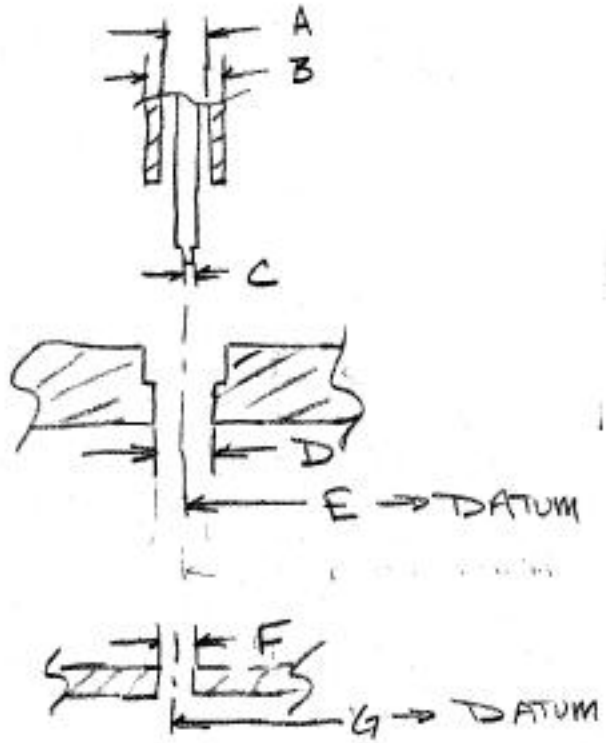
$$= 2(2.855 - 2.849) + 0.056 - 0.049 + 0.195$$

$$= 0.214$$

$$C = {}^{0.214}_{0.199} \cong \underline{0.207 \pm 0.007}$$

TREVOR GOULDING BPM DESIGN 1/19/00

DETERMINE THAT C'BORE WILL ADEQUATELY SEAT FEED THRU

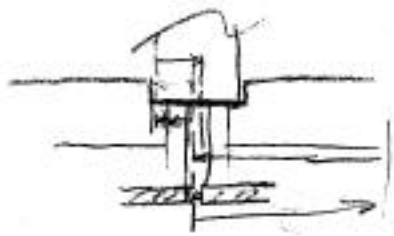


DIMENSIONS IN INCHES

A	(FEED THRU)	0.142 ± 0.001
B	(FEED THRU)	0.194 ± 0.001
C	(FEED THRU)	0.050 ± 0.001
D	(TUBE HOLE)	0.142 ± 0.003
E	(TUBE HOLE)	2.852 ± 0.003
F	(SPOOL HOLE)	0.054 ± 0.002
G	(SPOOL HOLE)	2.852 ± 0.003
H	(GAP)	

FEED THRU WALL THICKNESS

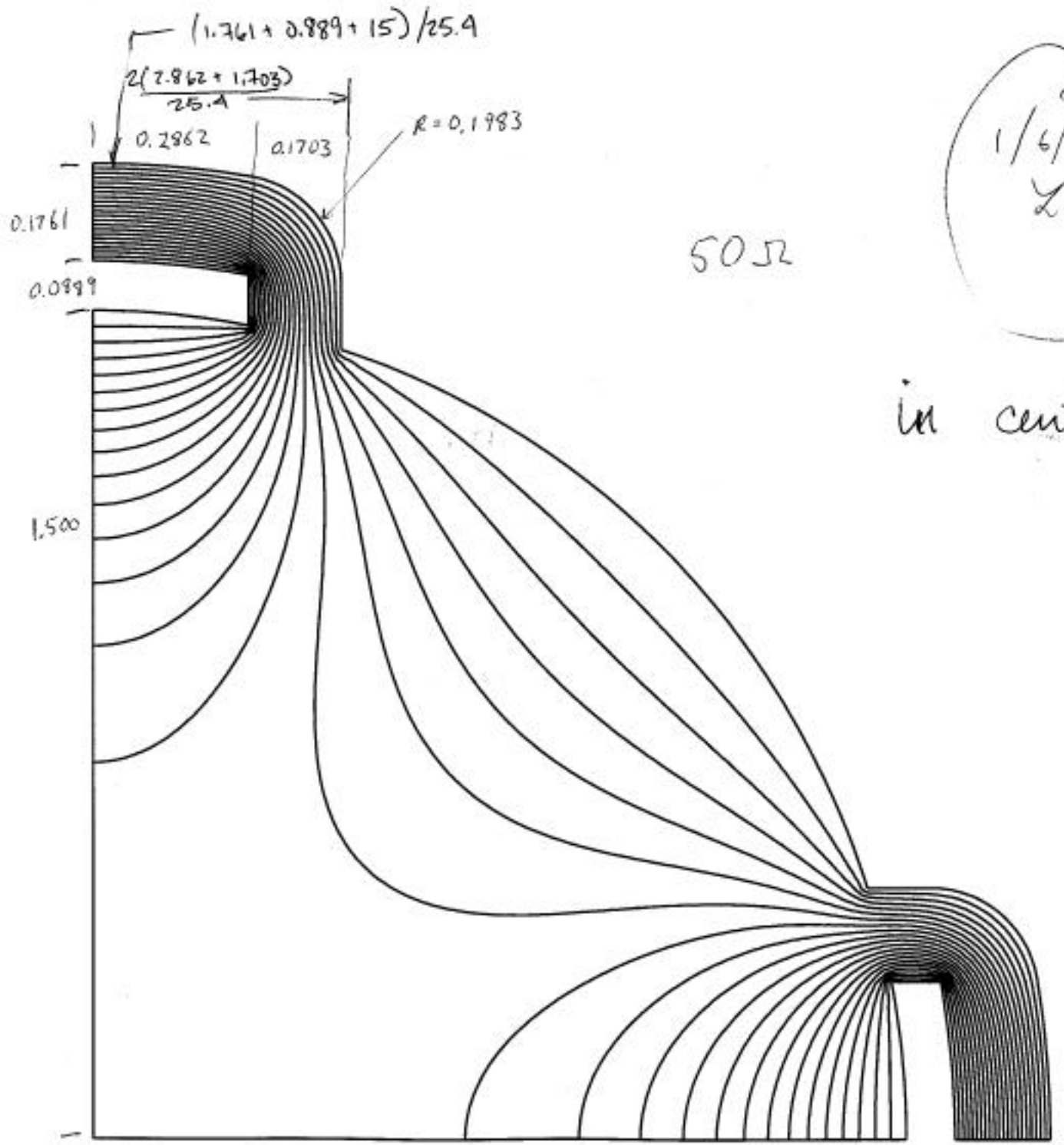
$$WALL_{MIN} = 1/2 (A_{MIN} - B_{MAX})$$
$$= 1/2 (0.193 - 0.193)$$
$$= 0.025$$



WORST CASE ENGAGEMENT

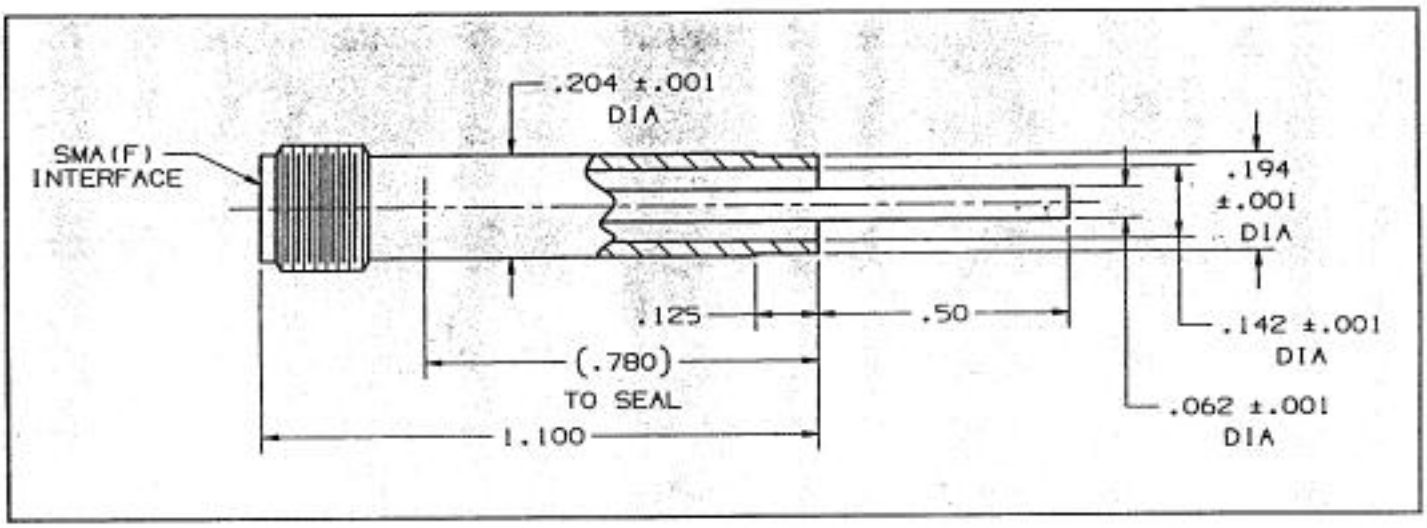
$$H = 1/2\, B_{MIN} + 1/2\, C_{MIN} - 1/2\, F_{MAX} + G_{MIN} - E_{MAX} - 1/2\, D_{MAX}$$
$$= (1/2)\, 0.193 + (1/2)\, 0.049 - 1/2\, (0.056) + 2.849 - 2.855 - (1/2)\, 0.145$$
$$= 0.015$$

$$\%\ \text{TOTAL WALL ENGAGEMENT} = \frac{WALL_{MIN} + H}{2(WALL_{MIN})} (100)$$
$$= \frac{0.025 + 0.015}{2(0.025)}$$
$$= 80\ \%$$ okay


(1.761 + 0.889 + 15) / 25.4
2(7.862 + 1.703) / 25.4
0.2862
0.1703
R = 0.1983
0.1761
0.0889
1.500
50 Ω
1/6/00
LRD
in centimeters
ITEM-PRODUCTS.COM
stripline bpm
CYCLE = 490

Appendix D

ULTRA-HIGH VACUUM MICROWAVE FEED-THROUGH, SMA FEMALE



SPECIFICATIONS

Impedance: 50 ohms.

Frequency range: DC to 20 GHz.

VSWR: 1.03:1 max to 3 GHz;
1.15:1 max to 20 GHz.

Insertion loss: 0.10 dB max @ 3 GHz.;
0.50 dB max @ 20 GHz.

Insulation resistance: $>10^{12}$ ohms.

Voltage: 1,500 VRMS.

Operating temperature range:
Based on outer body material -
304 stainless steel: 77°K to 573°K
(-196°C to +300°C).
316 stainless steel: 4°K to 573°K
(-269°C to +300°C).
Inconel®: 77°K to 773°K (-196°C to +500°C).

Hermeticity: $<1x10^{-11}$ cc He/sec.

Radiation: >200 megarads gamma.

Connector interface: SMA per MIL-C-39012.

Materials:
Outer body: 304 stainless steel, 316L stainless steel, or Inconel®.
Center conductor: TZM molybdenum per ASTM B365.
Insulator: AL_20_3 strengthened boro-silicate seal (130,000 psi compressive strength).
Connector contact: Gold-plated BeCu.

Weldability: Laser, e-beam, TIG.

Custom materials: Cupronickel, monel, and titanium.

KAMAN
INSTRUMENTATION
MICROWAVE PRODUCTS GROUP

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